

**BIG CHIEF – GOLCONDA MINE SITE  
JEFFERSON COUNTY, MONTANA**

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## **1.0 INTRODUCTION**

The Big Chief-Golconda Mine site is located along Golconda Creek in Jefferson County, Montana approximately 12 miles southeast of Helena, Montana. The mine is situated in the Elkhorn Mountains, east of Interstate 15 and Jefferson City (Figure 1-1). The Big Chief-Golconda Mine site was a historical producer of lead and zinc with some precious metals. The Big Chief-Golconda Mine site is bordered to the east by Golconda Creek. The mine is one-quarter mile south on Golconda Creek Road from its junction with Tizer Lake Road.

Subsequent use of the land has primarily involved recreation. The site has a main cabin, pole barn, sheds and other structures as depicted in Figure 4-1. The cabin and grounds are used by the Fehlig family of Helena, Montana for summer recreation and fall hunting.

### **1.1 PURPOSE OF RECLAMATION INVESTIGATION AND EXPANDED ENGINEERING EVALUATION REPORT AND COST ANALYSIS REPORT**

The Big Chief-Golconda Mine site consists of approximately 1.5 acres of metal mining impacted lands. Four distinct waste areas and potential contaminated media (surface water contamination, surface soil contamination, subsurface soil contamination, and sediment contamination) are present at this site. Based on the Abandoned Mines Hazardous Material Inventory completed by Montana Department of Environmental Quality, Mine Waste Cleanup Bureau (DEQ/MWCB 2004), approximately 5,000 cubic yards (CY) of decomposed granodiorite waste rock and gangue ore are located within the site boundary, including erosional remnants of oxidized waste rock piles in Golconda Creek. Minimally contaminated sediments were also identified downstream from the mine site.

As part of the Abandoned Mine Hazardous Materials Inventory (HMI), soil, sediment and surface water samples were collected at the Big Chief-Golconda Mine site. Arsenic, copper, manganese, lead and zinc were found at levels of potential concern in the majority of the soil samples collected. In addition, the concentration of dissolved lead in a surface water sample collected near the center of the primary disturbance (SW-002) was found to be higher than the Montana water quality standard for human health (DEQ 2001). Based on these samples and other considerations, the DEQ/MWCB decided to prepare a Reclamation Investigation (RI) and Expanded Engineering Evaluation and Cost Analysis (EEE/CA) report to address environmental impacts associated with the disposal of the metal mining wastes associated with the Big Chief-Golconda Mine site.

Figure 1-1      Big Chief – Golconda Mine site Location Map

This RI and EEE/CA report has been prepared as a functional guide for conducting full-scale reclamation at the Big Chief-Golconda Mine site. The reclamation activities proposed for the project site were developed as part of a comprehensive reclamation procedure (Figure 1-2). This reclamation procedure complies with the requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA). The procedure streamlines certain aspects of the process to meet the regulatory requirements to clean up abandoned mine sites.

## **1.2 ORGANIZATION OF INVESTIGATION**

Existing data available for the Big Chief-Golconda Mine site have been evaluated and permission from owners to access property has been obtained by DEQ. The Reclamation Investigation and Evaluation Report is organized into six sections. The references are presented at the end of each section, which document the publications and materials used in the preparation of these sections. The contents of each section are briefly described below.

*Section 1.0 Introduction* - This section presents the purpose, organization, and management of the Big Chief-Golconda Mine investigation.

*Section 2.0 Environmental Setting* - This section describes the location of the Big Chief-Golconda Mine site, including (1) climatic, geologic, and hydrologic characteristics of the site; (2) the biological setting such as the wildlife resources and the vegetation indigenous to the area; (3) threatened and endangered species concerns; and (4) present land uses and local population.

*Section 3.0 Description of Property* - This section presents a summary of past metal mining activities and the results of any past sampling and characterization at the site. The estimated types, volumes, and contaminant concentrations from existing data are provided. Ownership information and cultural issues are also provided in this section.

*Section 4.0 Reclamation Work Plan* - This section presents the reclamation work plan for the Big Chief-Golconda Mine site, including (1) preliminary reclamation objectives and goals; (2) the field sampling plan; (3) the quality assurance protocol plan; (4) the laboratory analytical plan; and (5) the health and safety plan.

Figure 1-2      Big Chief – Golconda Mine site Comprehensive Reclamation Procedure

*Section 5.0 Reclamation Investigation* - This section presents the results of the reclamation investigation field activities, including (1) site and waste characterization; (2) reclamation and land use characterization; (3) human health risk assessment; (4) ecological risk assessment; and (5) conclusions.

*Section 6.0 Expanded Engineering Evaluation and Cost Analysis* - This section presents a detailed analysis of reclamation alternatives that regulatory agencies can use for reclamation decision-making, including (1) reclamation objectives and goals; (2) applicable or relevant and appropriate requirements; and (3) the development and screening of reclamation alternatives.

### **1.3 PROJECT MANAGEMENT**

The DEQ/MWCB and Tetra Tech EM Inc. team of professionals working on the investigation and evaluation of the Big Chief-Golconda Mine site is presented in Section 1.3.1. The preliminary schedule for completing tasks and submitting plans and reports is presented in Section 1.3.2.

#### **1.3.1 Project Team**

The successful completion of this project requires the continual cooperation between DEQ/MWCB and Tetra Tech EM Inc. personnel. The DEQ/MWCB and Tetra Tech EM Inc. personnel working on this project are presented in Table 1-1.

**TABLE 1-1  
PROJECT TEAM  
BIG CHIEF – GOLCONDA MINE SITE**

<b>Agency/Firm</b>	<b>Personnel</b>	<b>Project Title</b>	<b>Contact Information</b>
Montana Department of Environmental Quality/Mine Waste Cleanup Bureau	Vic Andersen	Bureau Chief	841-5025
	Dale Herbort	Big Chief-Golconda Mine Site Project Manager	841-5028
Tetra Tech EM Inc.	Chris Reynolds	Program Manager Quality Assurance Manager Field Laboratory Supervisor	442-5588
	J. Edward Surbrugg	Project Liaison/Project Manager	
	Joe Faubion	Field Team Leader	
	Matt Hulbert	Field Team Member	
	Laura Newman, P.E.	Field Team Member	
	Dan Shaffer	Field Team Member	
	Jessica Allewalt	Field Team Member	
	Gary Sturm, P.E.	Project Engineer	
	Aaron Cade	Technical Support Team Member	
	Alicia Stickney	Technical Support Team Member	

The responsibilities of the DEQ/MWCB and Tetra Tech EM Inc. project team members are presented below.

**Mine Waste Cleanup Bureau Personnel Responsibilities:**

- **Bureau Chief** - The bureau chief administers all MWCB activities.
- **Project Manager** - The MWCB project manager will monitor the performance of the contractor, review and approve QA measures, and provide direction to the Tetra Tech EM Inc. project liaison, project manager, and field team leader.

**Tetra Tech EM Inc. Personnel Responsibilities:**

**Program Manager** - The program manager will administer all project activities, staffing, and budgets.

- **Quality Assurance Manager** - The quality assurance manager will review all work products for technical quality and consistency.
- **Project Liaison** - The project liaison will coordinate project activities with the MWCB project manager.
- **Project Manager** - The Tetra Tech EM Inc. project manager will oversee project field activities and work products. The project manager/project liaison will keep the field team informed of all project activities.
- **Field Laboratory Supervisor** - The field laboratory supervisor will oversee field analytical activities and will coordinate with the project manager and field team leader to complete the field activities. The field laboratory supervisor will also coordinate data review, validation, and auditing requirements.
- **Field Team Leader** - The field team leader will oversee the field sampling activities and coordinate with the property owners to schedule all field activities.
- **Field Team Members** - The field team members will assist the field team leader and field laboratory supervisor to complete the field activities.
- **Project Engineer** – The project engineer will have primary responsibility for completing the engineering evaluation and the development and screening of reclamation alternatives.
- **Technical Support Team Members** - The technical support team members will assist the Tetra Tech EM Inc. project manager to complete all work products.

### **1.3.2 Project Schedule**

The preliminary project schedule is presented in Table 1-2. This schedule assumes that the work assignments and agency review proceed in a steady and continuous manner.

**TABLE 1-2**  
**PROJECT SCHEDULE**  
**BIG CHIEF – GOLCONDA MINE SITE**

<b>Document Submittal and Task</b>	<b>Date</b>
Draft Reclamation Work Plan	March 25, 2005
Final Reclamation Work Plan	April 10, 2005
Reclamation Field Activities	April 2005
Draft Reclamation Investigation Report	May 10, 2005
Final Reclamation Investigation Report	May 25, 2005
Draft Expanded Engineering Evaluation/Cost Analysis Report	May 25, 2005
Final Expanded Engineering Evaluation/Cost Analysis Report	June 10, 2005

#### **1.4 REFERENCE CITED**

Montana Department of Environmental Quality (DEQ). 2004. Montana Numeric Water Quality Standards (Circular WQB-7). January.

Montana Department of Environmental Quality – Mine Waste Cleanup Bureau (DEQ/MWCB), 2004. Abandoned Hard Rock Mine Priority Site Investigation and Hazardous Materials Inventory. Big Chief-Golconda Mine Site, Jefferson County, PA 049020. Completed by Tetra Tech EM Inc.

**BIG CHIEF-GOLCONDA MINE SITE  
HELENA, MONTANA**

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## **2.0 ENVIRONMENTAL SETTING**

The environmental setting of the Big Chief-Golconda Mine site is provided in the following sections (Section 2.1 through 2.7). The references cited in Section 2.0 are presented in Section 2.8.

### **2.1 SETTING**

The Big Chief-Golconda Mine site is located on the western edge of the Elkhorn Mountains, in Jefferson County, Montana. (Figure 1-1). The Big Chief-Golconda Mine is situated at an elevation of approximately 4,980 feet above mean sea level (amsl) in Section 17, Township 7 North, Range 3 West, Montana principle meridian (Latitude North 46.3586°; Longitude West 112.01° ). The Big Chief-Golconda Mine site is comprised of approximately 1.5 acres of metal mining impacted land along Golconda Creek. A general location and topographic view of the site is presented in Figure 1-1 and a detailed site map of the entire project area is provided in Figure 4-1 (see Section 4).

### **2.2 CLIMATE**

The Big Chief-Golconda Mine site is situated approximately 15 miles east of the Continental Divide near the north end of Golconda Creek at an elevation of approximately 4,980 feet amsl. The mine site bounds closely the west side of the moderately incised drainage of Golconda Creek one-quarter mile south of the confluence of Golconda Creek and Prickly Pear Creek. The surrounding area consists of relatively steep mountain slopes, moderately sloped hillsides and rounded bouldery terrain. The climate of the Big Chief-Golconda Mine area is a modified continental climate similar to that of the Helena Valley. The cool air and general protection provided by the surrounding mountains contribute to less seasonal variation in temperature than would be typical of a true continental climate.

Climate information was obtained from the Western Regional Climate Center (WRCC) located at the Helena, Montana airport. Average monthly temperatures range from a high of 83°F to a low of 54°F in July and a high of 30°F to a low of 11°F in January. Average annual precipitation is roughly 12 inches a year. Average monthly precipitation exceeds 1 inch during May through September. The wettest months of the year are May and June. Precipitation is mostly in the form of snow in the winter months, snow and rain in the spring and fall, and rain in the summer.

## **2.3 GEOLOGY AND SOILS**

The lower portion of the Big Chief-Golconda Mine site is located within the Golconda Creek floodplain, approximately one-half mile south of the Prickly Pear Creek. The site adjoins a wetland area at the foothills of the northern Elkhorn Mountain Range. The mine exploited exposed tabular quartz veins trending east-west in outcropping cretaceous granodiorite of the Boulder Batholith. Thin veneers of poorly developed soils are typical in the area of heaviest disturbance. The parent materials for the soils that developed at this site are in-situ, or “grus,” the fragmental products of in-situ granular disintegration typical of granitic rocks.

The soil mapped at the Big Chief-Golconda Mine site is the Cowood-Hanks-Comad soil association, 0 to 2 percent slopes (USDA-NRCS 2003). This soil is classified as representative of soils that have developed from gravelly residuum weathered from granite (granodiorite) of the Boulder Batholith on slopes of 25 to 60 percent. These soils occur on mountainous hillsides, ridges, and divides and are generally shallow soils with bedrock at 10 to 20 inches. Outcrops of granodiorite boulders are common, especially in areas with the steeper slopes (USDA-NRCS 2003).

## **2.4 HYDROGEOLOGY**

The Montana Bureau of Mines and Geology Groundwater Information Center (GWIC) database lists 17 well logs within a one-mile radius of the Big Chief-Golconda Mine site. All of these wells appear to be used to supply domestic water to rural residences.

## **2.5 HYDROLOGY**

The Big Chief-Golconda Mine site is located within the watershed of Golconda Creek, near its confluence with Prickly Pear Creek. Winter snowmelt and storm water runoff combined with spring and seep flows make Golconda Creek a perennial stream. A wetland area adjoins the site at the slope break south of the main cabin.

## **2.6 VEGETATION AND WILDLIFE**

The Big Chief-Golconda Mine site is characterized by native and introduced species of vegetation. These include hardy and metal-tolerant species which are found growing on the disturbed and undisturbed areas.

Dominant trees on site include chokecherry (*Prunus virginiana*), aspen (*Populus tremuloides*), Ponderosa pine (*Pinus ponderosa*), and willow (*Salix* spp.). Shrubs and grasses include woods rose (*Rosa woodsii*), poison ivy (*Rhus radicans*), smooth brome (*Bromus inermis*), redtop (*Agrostis alba*), and tufted hairgrass (*Deschampsia caespitosa*). Other trees, shrubs, and forbs are found across and around the site in lower densities.

The Big Chief-Golconda Mine site provides habitat for fish and other aquatic organisms in flowing surface waters, rabbits, rodents, and reptiles. Many mule deer, elk and moose frequent the site year-round. Black bears also inhabit the area. Many species of birds are found around the site throughout the year. No threatened or endangered species are known to frequent the area.

## **2.7 LAND USE AND POPULATION**

The Big Chief-Golconda Mine site is located in a rural area which is served by electrical and telephone utilities. Primary land uses in the area are recreational and residential. Estimated population in a one-mile radius from the site is less than 250.

## **2.8 REFERENCES CITED**

Groundwater Information Center (GWIC). 2003. "Well Log List in T10N, R4W, Section 23, with a 1-Mile Buffer." Accessed on March 24, 2004. On-Line Address: <http://mbmggwic.mtech.edu/>

U.S. Census Bureau. 2000. "2000 U.S. Census Estimate."

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS). 2003. Soil Survey of Jefferson County, Montana.

Western Regional Climate Center (WRCC). 2005. "Helena, Montana Period of Record Monthly Climate Summary." Accessed on January 28, 2005. On-Line Address: <http://www.wrcc.dri.edu/summary/climsmmt.html>

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### **3.0 DESCRIPTION OF THE PROPERTY**

The Big Chief-Golconda Mine Site is comprised of approximately 1.5 acres of land that has been impacted by past metal mining. The site consists of privately owned patented mining claims. The history of the Big Chief-Golconda Mine site is provided in Section 3.1. Section 3.2 presents a description of the current property, including site waste characteristics and historical features. Section 3.3 presents information about the two State-owned uses for the Big Chief-Golconda Mine Site. The references cited in Section 3.0 are provided in Section 3.4.

#### **3.1 BIG CHIEF – GOLCONDA MINE SITE HISTORY**

The Big Chief Mine (M.S. 2574) was a small precious and base-metal producer, whose operations can best be described as sporadic. The vein follows a fracture in bleached and softened granodiorite, and the surface expression of the old workings indicates that the vein has an east strike and nearly a vertical dip. Minerals in the vein are pyrite, galena, minor stibnite, and principally the iron-bearing variety of sphalerite known as marmatite or “blackjack.” Six ore samples taken by the Montana Bureau of Mines and Geology in 1960 from the shaft and adit dumps assayed as follows: gold, 0.054 ounces per ton (opt), silver 0.46 opt. Lead assayed at 0.9 percent: and zinc, 1.9 percent. (MBMG 1960).

Originally located in 1882, the Big Chief mining claim was acquired by the Big Chief Tunnel and Mining Company three years later. During the following five years, two shafts, estimated to be 50 to 100 feet deep, sunk on the vein and an adit drift about 750 feet long was driven. These workings are now caved and inaccessible. Records of production during these quite likely most productive years are lacking.

The Big Chief Tunnel and Mining Company had abandoned the property by 1891 and it was subsequently lost to back taxes. In 1913, the Alta Corbin Copper Company acquired the Big Chief mining claim and may have been responsible for the 1919 recorded production.

In 1940, Mr. John Pasini purchased the Big Chief and began the longest period of ownership by a single party (other than Jefferson County) since the claim was located. Mr. Pasini mined the property on a small scale after World War II, but used the land more as a residence and goat farm than for mining. Mr. Pasini drove an adit about 100 feet long in 1948 near the creek level below the old main adit. The ore was narrow in this adit so the work was abandoned.

In the late 1950's, while Pasini still held the property, Dan Pyfer mined the Big Chief for a single season, but did not record substantial production (RTI 2005). The Big Chief claim was last operated as a metal mine by Dan Pyfer of Whitehall, Montana in 1957.

Recorded production since 1919 amounts to 114 tons of ore yielding 30 ounces of gold, 772 ounces of silver, 875 pounds of copper, 23,800 pounds of lead, and 11,922 pounds of zinc. Totals are for 8 producing years (1919, 1946-1950, 1952, and 1957).

### **3.2 DESCRIPTION OF THE CURRENT PROPERTY**

The site is located on an east facing slope. The mine site has two upper collapsed shaft and two lower collapsed adits. Waste rock dumps are primarily iron and manganese stained variably silicified granodiorite which is highly weathered and decomposed. Some highly oxidized sulfides are visible in quartz gangue. A surface spring (Fehlig Cabin Spring) flows seasonally at the southeast corner of the largest waste rock dump. Remnant waste rock piles exist close to the margins of Golconda Creek. No drainage from the collapsed adits was noted during the site inspection.

The Big Chief-Golconda Mine Site is easy to access. An unlocked wooden gate at the entrance exists as an animal barrier. The mine site property along the road paralleling Golconda Creek is not fenced. A recreational cabin and associated outbuildings exist on the site and are used by members of the Fehlig family of Helena, Montana. The site has been used exclusively as a seasonal residence and recreational property since the early 1960s.

#### **3.2.1 Waste Characteristics**

Tetra Tech EM Inc. completed a site inspection and hazardous materials inventory for DEQ-MWCB in 2004 (DEQ-MWCB 2004). As part of this inspection and inventory, Tetra Tech EM Inc. collected 20 samples from all wasterock dumps and scattered remnants of wasterock piles in the streambed of Golconda Creek at the Big Chief-Golconda Mine; and three co-located surface water/stream sediment samples.

The metals in the waste rock samples were dissolved from the matrix into an aqueous solution by acid digestion as described in Method 3050B - Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (EPA 1996). This digestion method involves a combination of nitric and hydrochloric acids

plus the addition of hydrogen peroxide to assist in degrading organic matter in the samples. Method 3050B digestion is not a “total” digestion, but is instead a solubilization of “environmentally available” metals.

ICP-AES metals analysis was used to determine the target metals concentrations in all soils, sediments, and water samples. Method 6010B was employed for the analysis of arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, and zinc. Method 6020 was used for all antimony analyses. Method 7471B returned results for mercury. The ICP-AES technique is a widely available metals analysis for samples that may have wide ranging metals concentrations and other matrix interferences.

The analytical results of the metals analyses are presented in Table 3-1. Approximately 5,000 cubic yards of granodiorite waste rock were estimated within the site. No significant segregated ore piles were identified. The waste rock sample with the highest concentration of metals was BC-002 taken from 1 to 2 feet depth. The site of BC-002 is coincident with the side of the dump from which ore would have been hauled out, and may be the base remnant of a historical ore pile site. Stream sediments with a slightly elevated concentration of lead were identified in Golconda Creek very near the area of main disturbance at the site of the lower collapsed adit.

### **3.2.2 Significant Historical and Cultural Features**

No significant historical or cultural features exist at the Big Chief Mine Site. Two 1910-1920 circa log structures are in place on the property and are associated with past mining activity. Neither structure is in good repair, nor could be categorized as remarkable culturally or historically (RTI 2005). The cabin on the site was constructed of logs and mortar in the early 1950’s according to Eric Fehlig of Helena, MT. The outbuilding immediately north of the cabin was used to age homemade cheese by Mr. Pasini.

## **3.3 OWNERSHIP INFORMATION**

Details of ownership and a detailed boundary survey map are pending completion of a site survey by DJ&A of Helena, Montana. The Fehlig family leases the recreational property on the Big Chief mine parcel from the J Patrick Hunt Family Trust of Ross, CA.. Mineral rights to the patented Big Chief mine claim (M.S. 2574) are held by Terra De Alta Inc. Profit Sharing. (MT Cadastral Mapping Program 2005)

**TABLE 3-1**  
**HISTORIC LABORATORY ANALYTICAL RESULTS**  
**BIG CHIEF – GOLCONDA MINE SITE**

Sampling Entity	Date	Sample ID	Sample Media	Units	Depth (ft)	Arsenic	Copper	Manganese	Lead	Zinc
Tetra Tech EM Inc.	9/23/2004	BC-1	Waste Rock	mg/kg	2	<10	20	1300	363	762
		BC-2			2	153	883	58	32300	936
		BC-3			3	55	141	1370	3750	1120
		BC-4			6	46	241	107	5500	518
		BC-5			3	17	91	3240	1360	12300
		BC-6			7	23	90	4630	1670	9940
		BC-7			10	<10	49	1080	207	847
		BC-8			12	90	106	61	5710	973
		BC-9			3	83	65	537	3730	400
		BC-10			7	56	43	630	2450	409
		BC-11			10	43	126	1550	7630	2360
		BC-12			15	50	92	565	2810	936
		BC-13			2	63	83	19	3220	341
		BC-14			3	<10	<10	1120	93	243
		BC-15			4	18	58	130	1410	231
		BC-16			3	35	239	286	3340	472
		BC-17			4	29	156	232	3560	356
		BC-18			5	26	217	491	2640	406
		BC-19			3	44	68	230	3140	463
		BC-20			7	62	42	338	2740	574
		BC-SD-001	Sediment	mg/kg	0.1	77	28	330	351	208
		BC-SD-002			0.1	52	27	298	794	211
		BC-SD-003			0.1	72	26	430	388	243
		BC-SW-001	Surface Water	mg/L	0.1	<0.003	<0.001	<0.005	<0.003	0.03
		BC-SW-002			0.1	<0.003	0.003	0.043	0.019	0.07
		BC-SW-003			0.1	<0.003	<0.005	<0.005	0.004	0.03

Notes:

ft        feet  
mg/kg   milligrams per kilogram  
mg/L    milligrams per liter

### **3.4 REFERENCES CITED**

- Montana DEQ. 2004. Montana Numeric Water Quality Standards (Circular WQB-7). January.
- Montana Bureau of Mines and Geology. 1960. Mines and Mineral Deposits (Except Fuels) Jefferson County, Montana. Bulletin 16 June, 1960. R.N. Roby, W.C. Ackerman, F.B. Fulkerson and F.A. Crowley.
- Montana Cadastral Mapping Program. 2005
- Renewable Technologies, Inc. (RTI). 2005. Historical Information for the Big Chief-Golconda Mine Site, Emailed communication from RTI to Mr. Dale Herbort, Project Manager at DEQ-MWCB, February 16.
- Tetra Tech, Inc. 1996. "Risk Based Cleanup Guidelines for Abandoned Mine Sites: Final Report." Prepared for the Department of Environmental Quality, Abandoned Mine Reclamation Bureau. February.
- U.S. Environmental Protection Agency (EPA). 1996. Method 3050B - Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, USEPA SW 846, U.S. Gov. Print. Office, Washington, DC.
- EPA. 1998. Method 6200 - Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment, USEPA SW 846, U.S. Gov. Print. Office, Washington, DC.

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## **4.0 RECLAMATION WORK PLAN**

The Montana DEQ/MWCB has instructed Tetra Tech EM Inc. to prepare a reclamation work plan that includes a field sampling plan (FSP), a quality assurance protocol plan (QAPP), a laboratory analytical plan (LAP), and a health and safety plan (HSP). This reclamation work plan has been prepared as a functional guide for conducting full-scale reclamation at the Big Chief – Golconda Mine site. The four supporting plans are presented in Sections 4.2 through 4.5. The references cited in Section 4.0 are presented in Section 4.6.

### **4.1 PRELIMINARY RECLAMATION OBJECTIVES AND GOALS**

The preliminary reclamation objectives and goals for the Big Chief – Golconda Mine site are discussed in the following sections.

#### **4.1.1 Preliminary Reclamation Objectives**

The overall objective of the Big Chief – Golconda Mine site reclamation project is to protect human health and the environment in accordance with the guidelines set forth by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Specifically, site reclamation must limit human and ecological exposure to mineral processing-related contaminants and reduce the mobility of those contaminants through associated solid media, sediment, and surface water exposure pathways. The final reclamation objectives, including the specific amount of contaminant exposure and mobility reduction required, will be determined after site characterization, risk assessment, and analysis of the applicable or relevant and appropriate requirements are completed.

#### **4.1.2 Preliminary Reclamation Goals**

Preliminary remediation goals (PRG) are contaminant-specific and media-specific numbers that reflect potential cleanup (reclamation) levels at the Big Chief – Golconda Mine site. PRGs have been established for the Big Chief – Golconda Mine site to guide investigation activities and to identify areas and media that may require reclamation. Water and solid matrix (soil and sediment) PRGs for the mine site are shown in Table 4-1 and Table 4-2, respectively. PRGs may be based on Federal and State water quality standards, sediment quality and screening values, or on risk-based concentration values. Federal and State water quality standards used to evaluate surface water and groundwater data include maximum

contaminant levels (MCL), non-zero maximum contaminant level goals (MCLG), freshwater chronic aquatic life standards (CALs), and Montana human health standards (HHS) for water. Sediment quality values are derived from the probable apparent effects thresholds (PAET) from bioassay studies in Oregon and Washington State (Washington State Dept. of Ecology). PRGs or cleanup guidelines have been developed by the U.S. Environmental Protection Agency (EPA) Region 9. The following sections present the water quality standards for surface water; the freshwater sediment quality values from Washington State, and the residential soil cleanup levels.

**TABLE 4-1**  
**PRELIMINARY RECLAMATION GOALS FOR SURFACE WATER (µg/L)**  
**BIG CHIEF – GOLCONDA MINE SITE**

Contaminant	CALS <sup>a</sup>	HHS <sup>b</sup>
Arsenic	150	18
Lead	3.2 <sup>c</sup>	15
Manganese	None	50

Notes:

- <sup>a</sup> CALS - Freshwater Chronic Aquatic Life Standards, Circular WQB-7, Montana Numeric Water Quality Standards (DEQ 2004)
- <sup>b</sup> HHS - Human Health Standards for Water, Circular WQB-7, Montana Numeric Water Quality Standards (DEQ 2004)
- <sup>c</sup> CALS assume water hardness of 100 mg/L for lead

**TABLE 4-2**  
**PRELIMINARY RECLAMATION GOALS FOR SOIL AND SEDIMENTS (mg/kg)**  
**BIG CHIEF – GOLCONDA MINE SITE**

Contaminant	EPA Region 9 Residential PRGs	Washington State Dept. of Ecology Freshwater Sediment Quality PAET Values <sup>a</sup>
Arsenic	0.39 (40) <sup>b</sup>	19
Manganese	1800	1400
Lead	400	240

Notes:

mg/kg                      milligrams per kilogram

- <sup>a</sup> Probable Apparent Effects Threshold (PAET) Values; (Washington State Dept. of Ecology 1997)
- <sup>b</sup> 0.39 is the arsenic Region 9 Residential PRG for the carcinogenic endpoint. The Montana DEQ uses a soil screening value of 40 mg/kg for arsenic based on background arsenic values for Montana soils.

## **Surface Water**

Surface water on the Big Chief – Golconda Mine site is found in Golconda Creek that flows along the eastern edge of the site. The creek is situated in a defined channel with surface water passing through erosional and excavated remnants of waste rock found along the creek bed. Surface water from Golconda Creek flows into Prickly Pear Creek, which contains some wetland areas downstream from the site.

Previous analyses of the surface water indicated an elevated lead concentration in the samples collected directly at the mine site and just downstream of the mine site (DEQ-MWCB 2004). Lead is a human health contaminant of concern. The previous surface water sampling results are presented in Section 3.2.1. Table 4-1 presents the surface water PRGs for metals of concern.

## **Solid Matrix Materials**

Analysis of solid matrix samples (which include soils, mineral processing wastes, and sediments) collected during the site inspection and hazardous materials inventory (DEQ-MWCB 2004) indicates that the mineral processing wastes contain concentrations of arsenic, manganese, and lead at levels of potential concern. The previous solid matrix sampling results are presented in Section 3.2.1.

Sediment samples collected during the site inspection and hazardous materials inventory (DEQ-MWCB 2004) indicate that concentrations of arsenic and lead are above sediment quality values (Washington State Dept. of Ecology 1997) and at levels of potential concern. There are currently no promulgated standards for metal concentrations in soil or sediment in Montana. To assist in investigation planning and reclamation option selection and development, EPA Region 9 has developed risk-based PRGs for metals in soil. In addition, the Montana DEQ has developed a conservative set of risk-based guidelines that are calculated for different contaminants using a recreational visitor exposure scenario. The guidelines take into account the possibility of exposure through multiple exposures. The PRGs are intended to help investigators plan reclamation actions but should not be used to determine site risks.

At other sites in Montana, the Montana DEQ has recommended the use of the freshwater sediment quality values published by the Washington State Dept. of Ecology (1997) for ecological screening levels. Action levels for soils and sediments at the Big Chief – Golconda Mine site will be determined based on the results from the human health and ecological risk assessments completed during the RI. The PRGs for the metals of concern in soils and sediments are listed in Table 4-2.

## **4.2 FIELD SAMPLING PLAN**

This FSP has been prepared as a guide for conducting the RI of the Big Chief – Golconda Mine site. The FSP presents sampling objectives and procedures, field analytical procedures, sample documentation and custody procedures, sample preservation and handling requirements, and decontamination procedures.

The purpose of the RI is to collect the information necessary to perform the risk assessments, to complete an expanded engineering evaluation and cost analysis (EEE/CA), and to select a reclamation alternative. Once the reclamation alternative has been selected, site- and alternative-specific engineering data may need to be collected to support design efforts.

Data collected to support the human health and ecological risk assessments will include:

- the magnitude and extent of surface and subsurface soil contamination
- the magnitude and extent of sediment contamination
- the magnitude of surface water contamination
- metals concentration in background soil

Data collected to complete the EEE/CA will include:

- accurate estimates of the area and volume of solid waste material requiring reclamation
- data to determine if waste material is classified as a Resource Conservation and Recovery Act (RCRA) hazardous waste
- data to determine reclamation requirements for disturbed areas including soil texture and grain size, liming requirements, fertilizer requirements, percent organic matter, and identification of native species
- location and characterization of potential repository sites
- location of potential cover soil borrow area

### **4.2.1 Sampling Objectives**

Surface soil, subsurface soil, and sediments with elevated metal concentrations are present at the Big Chief – Golconda Mine site. Table 4-3 lists the sample type, analysis, approximate number of samples that will be required to fulfill the sampling objectives, and number of contingency samples. Figure 4-1

shows the approximate sampling locations. The sampling objectives for the Big Chief – Golconda Mine site are:

- Determine the nature and extent of surface soil contamination. Samples will be collected to further define the locations of the contaminated materials that were identified during the site inspection and hazardous materials inventory (DEQ-MWCB 2004). Up to 2 additional opportunistic surface soil grab samples will be collected within or near visually identified edges of the waste rock areas. The two soil samples will be sent to the laboratory for total metals analysis.
- Determine the nature and extent of subsurface soil contamination. The thickness of contaminated waste rock sources was approximately defined during the site inspection and hazardous materials inventory (DEQ-MWCB 2004). To provide more accurate calculations of the volume of materials that may require removal, 2 additional backhoe pits will be completed in and around the identified waste source areas. Assuming that 2 samples are collected from each backhoe pit, 4 subsurface soil samples will be collected and analyzed for total metals at an offsite laboratory.
- Determine the location and distribution of metal-contaminated sediments in Golconda Creek. Two sediment samples will be collected from the creek bed, one upstream and one downstream from the central sediment sampling site used in the site inspection and hazardous materials inventory (location for BC-SW 002/BC-SD 002)(DEQ-MWCB 2004). Discrete grab samples will be collected using a stainless steel trowel. The two sediment samples will be decanted and sent to an offsite laboratory for total metals analysis.
- Determine the quality of surface water in Golconda Creek. Two additional surface water samples will be collected at the same locations as the two sediment samples and sent to an offsite laboratory for analysis.
- Determine the quality of groundwater to determine if metals have migrated from surface and subsurface materials to the groundwater at this site. One groundwater sample will be collected from the existing residential well and analyzed for total metals analysis at an offsite laboratory.

#### **4.2.2 Soil Sampling Procedures**

##### **Surface Soil**

Two additional surface soil grab samples will be collected at opportunistic locations within or near visually identified edges of the waste rock areas. Sample locations will be selected to further characterize the demarcation between the visually observable (contaminated) waste rock materials and the uncontaminated surface soil located a short distance away from the visual wastes. Sample locations used to characterize the waste materials will be selected based on visible characteristics including soil texture, iron staining, topography, and lack of vegetative cover. Additional sampling locations may be identified during the RI field effort.

**TABLE 4-3**  
**PROPOSED SOIL, SEDIMENT, SURFACE WATER, AND GROUNDWATER SAMPLES**  
**BIG CHIEF – GOLCONDA MINE SITE**

Sample Type	Analysis	Number of Samples	Number of Contingency Samples
Soil (0-3")	TAL Metals	2	1
	Particle size (texture)	2	1
	CEC	2	1
	Complete Agricultural (pH; conductivity; N-P-K; OM; lime and fertilizer requirement)	2	1
Subsurface Soil 2 backhoe pits 2 samples collected per pit; 1 in waste and 1 in buried soil	TAL Metals	4	1
	Particle size (texture)	2	1
	CEC	2	1
	Partial Agricultural (pH; N-P-K; texture; and lime requirement)	2	1
Background Soil (0-3")	TAL Metals	2	1
Sediment (0-1")	TAL Metals	2	1
Surface Water	TAL Metals	2	1
	Water Quality Parameters (pH, conductivity, hardness, chloride, sulfate)	2	1
Groundwater	TAL Metals	1	1
	Water Quality Parameters (pH, conductivity, hardness, chloride, sulfate)	1	1

Notes:

TAL Target analyte list (antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc)  
CEC Cation exchange capacity  
OM Organic matter

Figure 4-1 Existing and Proposed Sample Location Map

The two surface soil samples will be analyzed for 13 target analyte list (TAL) metals including: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc. The samples will be sent to an offsite laboratory for total metals analysis (ICP-AES methods). Both samples will also be analyzed for particle size (texture), cation exchange capacity (CEC) and complete agricultural (includes pH; conductivity; nitrogen-phosphorus-potassium; organic matter; lime recommendation; and fertilizer recommendation) because there is a probability that the soil may be reclaimed in place and not have total metals concentrations above the PRG values.

Table 4-3 lists the approximate number of samples that will be collected to characterize the extent of soil contamination. The soil sampling locations will be identified during the initial phase of the RI. All surface soil samples will be collected from 0 to 3 inches below ground surface with a trowel.

### **Subsurface Soil**

Subsurface soil samples will be collected to characterize the waste rock and to verify the depth of contamination and the thickness of the waste sources. Subsurface soil samples will be collected from two backhoe pits completed in and around the waste source areas at the Big Chief – Golconda Mine site. Proposed backhoe pit locations are shown on Figure 4-1. Two soil samples will be collected from within and below the waste rock material in each backhoe pit and analyzed for total metals using an offsite laboratory. The locations of the backhoe pits have been preliminarily identified based on the results from the site inspection and hazardous materials inventory (DEQ-MWCB 2004) and to provide additional coverage for areas not yet characterized. The results from the subsurface soil sampling will increase the accuracy of the waste volume calculations.

Up to two samples will also be analyzed for particle size (texture), CEC, and partial agricultural parameters. The samples submitted for these additional analyses will be selected as typical of the wastes and of the buried soils below the wastes. The samples submitted for partial agricultural parameters will be collected from the soil immediately below the wastes to assess the potential for metals leaching from the wastes and to determine the recommended lime and fertilizer requirements for these buried soils. Samples from within three feet of the surface will be collected from the trench walls by using a trowel to fill the sample containers. Samples from depths greater than three feet below ground surface will be collected from the backhoe bucket by using a trowel to fill the sample container. The locations of the two backhoe pits will be marked so that their locations can be included in the topographic survey to be completed by a separate party.

All soil sampling equipment will be decontaminated using the procedures described in Section 4.2.9 before collecting the next sample.

### **Background Soil Samples**

Two soil samples will be collected outside of the mining-impacted area to establish background metals concentrations. All surface soil samples will be collected from 0 to 3 inches below ground surface using the same methods used to collect the other surface soil samples. The background sampling locations will also be identified and included in the site topographic survey.

#### **4.2.3 Sediment Sampling Procedures**

The potential environmental/health risks and reclamation alternatives associated with sediment contamination at the Big Chief – Golconda Mine site will be evaluated by collecting grab samples at two additional locations in Golconda Creek. The sediment samples will be collected from the creek bed; one upstream and one downstream from the central sediment sampling location used in the site inspection and hazardous materials inventory (DEQ-MWCB). The sediment grab samples will be collected using a stainless steel trowel to collect sediments to a depth of about 6 inches (15 centimeters). Care will be taken to ensure that a sufficient volume of the finer sediment fraction is collected for analysis. All sediment samples will be decanted of excess water and sent to an offsite laboratory for total metals analysis. The proposed sediment sampling locations are shown on Figure 4-1.

#### **4.2.4 Surface Water Sampling Procedures**

The risk to potential receptors from surface water contamination will be evaluated during the RI. Three surface water samples were collected during the site inspection and hazardous wastes inventory (DEQ-MWCB 2004) and analyzed for total metals at an offsite laboratory. One water sample (BC-SW 002) had lead concentrations above the human health surface water standard of 0.015 milligrams per liter (mg/L) (DEQ 2004). In order to complete the ecological risk assessment during the RI, some additional water quality data (hardness, Cl, sulfate) are needed. Two additional surface water samples (co-located samples with sediment samples) are proposed to be collected for the RI. The risk to potential receptors will be evaluated using the previous surface water data and the additional RI water quality data. The surface water samples will be analyzed for the parameters listed in Table 4-3. The proposed surface water sampling locations are shown on Figure 4-1.

Surface water samples will be collected by dipping the sample container into Golconda Creek with the mouth pointed upstream. The surface water samples will not be filtered. Two separate sample containers will be filled; one for metals analysis and one for hardness, chloride, and sulfate determinations. The sample bottle designated for metals analysis will be preserved with nitric acid but the hardness, chloride, and sulfate sample bottle will not be preserved.

#### **4.2.5 Groundwater Sampling Procedures**

One groundwater sample will be collected from the existing well located east of the cabin. A hydrant is located at the well head and the sample will be collected directly from the hydrant. Water will be allowed to run for approximately five minutes before collecting the water sample by directly filling the sample bottle. The groundwater sample will be filtered at the laboratory through a 0.45 micron filter to determine the dissolved metal fraction. The groundwater sample will not be preserved with nitric acid in the field but will be preserved after filtering at the laboratory. The need for additional groundwater sampling will be evaluated and performed after the completion of this RI.

#### **4.2.6 Field Analytical Procedures**

Field analysis will be collected within Big Chief – Golconda Mine site at the sediment and surface water sampling locations. Field measurements will be recorded at each of the proposed co-located sediment and surface water locations and for the groundwater sample. The water quality parameters that will be measured in the field include pH, Eh, specific conductance, and temperature. The pH, Eh, specific conductance, and temperature will be measured with field portable meters. The instrument will be calibrated using the manufacturer's recommended procedures. The probes will be inserted into the water and the pH, Eh, specific conductance, and temperature readings will be recorded. Before every sample, a check standard will be measured to verify instrument calibration. Before every second sample, a series of three measurements will be made to check instrument response and precision.

#### **4.2.7 Sample Documentation and Custody**

The possession and handling of each sample will be properly documented to promote timely, correct, and complete analysis for all required parameters. To promote sample integrity, each sample will be traceable from the point of collection through analysis and final disposition.

The field records and documentation control measures to be used during sample collection, identification, handling, and shipping include the following:

- Sample labels
- Custody seals
- Field sample data and chain-of-custody record

The Tetra Tech EM Inc. field team leader is responsible for obtaining these items and distributing them to field personnel. All paperwork will be completed using indelible ink.

### **Sample Designation**

A sample numbering scheme has been developed that allows each sample to be uniquely identified and provides a means of tracking the sample from collection through analysis. The numbering scheme indicates the sample type, location, and depth (or interval depth). The unique sample number will be entered on sample labels, field tracking sheets, chain-of-custody forms, and other records documenting sampling activities. The following sample numbering system will be used for this investigation:

X-Y-Z

where:

- X = Sample Type (BG = background soil sample; BP = backhoe pit subsurface soil sample; SD = sediment sample; SS = surface soil sample; and SW = surface water sample)
- Y = Sample Location (for example, test pit number)
- Z = Depth only for subsurface soil samples (test pit)

for example: BP-01-10 would be a subsurface soil sample from test pit 01 collected at a depth of approximately 10 feet below ground surface.

A matrix spike/matrix spike duplicate (MS/MSD) will also be submitted to the offsite laboratory for analysis for each sample matrix. Surface water MS/MSD samples require triplicate volumes for each analyte. The sample designation for the MS/MSD surface water samples is identical to the normal sample; however, one suite of the triplicate volume will be labeled MS and the other volume MSD. Soil samples selected for MS/MSD analysis will be designated in a similar manner.

## **Field Logbook**

Daily field activities will be documented through journal entries in a bound field logbook, dedicated to the Big Chief – Golconda Mine site. Logbook entry and custody procedures will follow National Enforcement Investigation Center policies and procedures (EPA 1986). The logbook will be water-resistant, and all entries will be made in indelible ink. The logbook contains all pertinent information about sampling activities, site conditions, field methods used, general observations, and other pertinent technical information. Examples of typical logbook entries include the following:

- Personnel present
- Daily temperature and other climatic conditions
- Field measurements, activities, and observations
- Referenced sampling location description (in relation to a stationary landmark) and map
- Media sampled
- Sample collection methods and equipment
- Date and time of sample collection
- Types of sample containers used
- Sample identification and cross-referencing
- Sample types and preservatives used
- Analytical parameters
- Sampling personnel, distribution, and transporters
- Site sketches
- Instrument calibration procedures and frequency
- Visitors to the site

The Tetra Tech EM Inc. field team leader or designee will be responsible for the daily maintenance of all field records. Each page of the logbook will be numbered, dated, and signed by the person making the entry. Corrections to the logbook will be made by using a single strike mark through the entry to be corrected, then recording and initialing the correct entry. For corrections made at a later date, the date of the correction will be noted.

Color photographs taken during the sampling activities will be numbered to correspond to logbook entries. The name of the photographer, date, time, site location, and photograph description will be entered sequentially in the logbook as photographs are taken. Adequate logbook notations and receipts will be retained to account for custody during film processing.

## **Chain-Of-Custody Record**

A chain-of-custody record establishes the documentation necessary to trace sample possession from time of collection through sample analysis and disposition. A sample is in the custody of a person if any of the following criteria are met:

- The sample is in a person's physical possession.
- The sample is in a person's view after being in his or her physical possession.
- The sample was in a person's physical possession and was then locked up or sealed to prevent tampering.
- The sample is kept in a secured area.

The sample collector will complete a chain-of-custody record to accompany each sample delivery container (cooler) and will be responsible for shipping samples to the laboratory. The sample collector will provide the project number and the sample collector's signature as header information on the chain-of-custody record. For each station number, the sample collector will indicate the date, time, station location, number of containers, analytical parameters, and designated sample numbers. When shipping the samples, the sample collector will sign the bottom of the form and enter the date and time (military) that the samples were relinquished. The sample collector will enter the carrier name and air bill number on the form. The original signature copy of the chain-of-custody record will be enclosed in a plastic bag and secured to the inside of the cooler lid. A copy of the chain-of-custody record will be retained for Tetra Tech EM Inc. files.

Each cooler will be secured for shipment by placing custody seals across two sides of the cooler lid. Commercial carriers are not required to sign the chain-of-custody form, provided that the form is sealed inside the shipping cooler and the custody seals remain intact. The analytical laboratory will carry out the chemical analyses and are responsible for storing the samples in a secure location and following all chain-of-custody procedures.

## **Sample Shipment**

All samples will be packaged and labeled for shipment in compliance with current regulations. Only metal or plastic ice chests will be used for shipping samples. The samples will be placed in the cooler and padded with bubble wrap to absorb shock. The chain-of-custody form will then be placed in a sealed

plastic bag and taped to the inside of the cooler lid. The ice chest will be securely taped shut and the custody seals and shipping airbill will be attached.

#### **4.2.8 Sample Preservation and Handling**

The preservation and holding time requirements for the samples and analysis described in Sections 4.2.1 through 4.2.5 are listed in Table 4-4.

#### **4.2.9 Decontamination Procedures**

Decontamination will be required for all sampling equipment, personal protective gear, and field monitoring equipment used during field activities. Sampling equipment will be decontaminated between collection of each sample. Liquinox or Alconox cleaning solutions and distilled water rinses will be used for all sampling equipment and tools. Decontamination procedures for specific equipment used in association with field activities are described in the following sections.

##### **Excavation Equipment**

All excavation equipment will be decontaminated at designated locations within the Big Chief – Golconda Mine site. The decontamination locations will be identified before fieldwork begins. Decontamination will be performed before excavation operations begin and between excavation pit locations. Decontamination will consist of removing any residual soil within the backhoe bucket.

##### **Sampling Equipment**

All non-disposable sampling equipment will be decontaminated before and after use. Sampling equipment may include shovels, sediment sampler, and hand trowels. Laboratory-supplied sample containers are provided precleaned and will not require decontamination.

**TABLE 4-4**

**SAMPLE COLLECTION, PRESERVATION, AND HOLDING TIME REQUIREMENTS  
BIG CHIEF – GOLCONDA MINE SITE**

<b>Matrix</b>	<b>Analyte</b>	<b>Preservation</b>	<b>Holding Time</b>	<b>Sample Size</b>	<b>Bottle</b>
Soil	EPA 6010 TAL Metals	Cool to 4°C	180 days; Hg 28 days	8 ounce	8-ounce polyethylene
Water	EPA 6010 TAL Metals	Cool to 4°C, HNO <sub>3</sub> to pH <2	180 days; Hg 28 days	1 liter	1-liter polyethylene
Soil	Particle Size	None	None	4 ounce	4-ounce polyethylene
Soil	Cation Exchange Capacity	None	None	4 ounce	4-ounce polyethylene
Water	Total Dissolved Solids <sup>b</sup>	Cool to 4°C	7 days	1 liter	1-liter polyethylene
Water	Hardness <sup>b</sup>		28 days		
Water	Alkalinity/Acidity <sup>b</sup>		7 days		
Water	Sulfate <sup>b</sup>		28 days		
Water	Chloride <sup>b</sup>		28 days		
Water	Nitrate/Nitrite	Cool to 4°C H <sub>2</sub> SO <sub>4</sub> to pH < 2	28 days	250 milliliter	250-milliliter polyethylene

Notes:

<sup>a</sup> Analytes can be analyzed from the same 4-ounce sample bottle

<sup>b</sup> Analytes can be analyzed from the same 1-liter sample bottle

TAL Target analyte list

H<sub>2</sub>SO<sub>4</sub> Sulfuric acid

°C Degree Celsius

HNO<sub>3</sub> Nitric acid

EPA Environmental Protection Agency

In general, the following procedures will be used for sampling equipment decontamination:

- Scrub the sampling equipment in a bucket using a stiff brush and Liquinox or Alconox solution with potable water.
- Triple-rinse the sampling equipment with potable water.
- Final rinse the sampling equipment with distilled water and allow to air dry in a clean dust-controlled area.
- Store the equipment in clean plastic bags until the next sampling event.

### **4.3 QUALITY ASSURANCE PROTOCOL PLAN**

This QAPP has been prepared to support the reclamation work plan and field sampling plan and describes the quality assurance (QA) for the RI of the Big Chief – Golconda Mine site. This QAPP presents the data quality objectives; QA objectives; QA sample collection procedures; sample documentation and custody; equipment operation, maintenance, and calibration; analytical procedures; data reduction, validation, and reporting; and corrective action procedures.

#### **4.3.1 Data Quality**

Data quality objectives (DQO) are qualitative and quantitative statements that specify the quality of the data required to support the RI activities. The data quality objectives for the project and the type, analytical level, and use of the data are presented below.

##### **Data Quality Objectives**

DQOs were prepared using EPA guidance for the data quality objectives process (EPA 1994). The EPA guidance (1994) presents the DQOs as a seven-step process:

**Step 1 - State the Problem.** Concisely describe the problem to be studied.

**Step 2 - Identify the Decision.** Identify what questions the study will attempt to resolve and what actions may result.

**Step 3 - Identify the Inputs to the Decision.** Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.

**Step 4 - Define the Study Boundaries.** Specify the time periods and spatial area to which the decisions will apply.

**Step 5 - Develop a Decision Rule.** Define the statistical parameter of interest, specify the action level, and integrate the previous DQO outputs into a single statement that describes the logical basis for choosing among alternative actions.

**Step 6 - Specify Tolerable Limits on Decision Errors.** Define the decision maker's tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.

**Step 7 - Optimize the Design.** Evaluate information from the previous steps and generate alternative data collection designs.

The following paragraphs describe each step, as listed above, and how it pertains to the investigation of the Big Chief – Golconda Mine site.

### **Step 1: Stating the Problem**

The Big Chief – Golconda Mine is an abandoned mine site located southwest of Jefferson City, Montana. Mine waste rock has been disposed of at this site which contains elevated concentrations of arsenic, manganese, and lead. Preliminary evaluation of site risks using the abandoned inactive mine scoring system (AIMSS) suggests that the waste rock may pose an unacceptable risk to groundwater and surface water receptors and human recreational users. The objective for the project is to protect human health and the environment in accordance with the guidelines set forth by the NCP.

### **Step 2: Identify the Decision**

Previous data and inspection of the site reveal that waste rock with levels of arsenic and lead are found at this site. In addition, sediment samples collected from Golconda Creek have elevated arsenic and lead concentrations. One surface water sample was found to have slightly elevated levels of lead. These materials may cause adverse impacts to human health and the environment. The following decisions will be made: What reclamation action is necessary at the site to protect human health and the environment? What is the areal extent and volume of waste rock and metal contaminated soil and sediment? How will the characteristics of the mine waste rock and underlying soil impact revegetation of the site? How will the physiography of the site affect reclamation alternatives? Are there suitable repository sites and soil borrow areas near the site?

### **Step 3: Identify the Inputs to the Decision**

The areal extent of waste rock and metal contaminated soil and sediments, and the characteristics of soil underlying the wastes will be determined by analyzing soil, sediment, surface water, and groundwater samples for metals and reclamation parameters. The volume of wastes and the physiography of the site will be determined by completing a survey of site topography and site features. Potential repository sites and soil borrow areas will be identified and the site characteristics will be determined through the excavation of test pits and the collection of soil samples for agronomic analyses.

### **Step 4: Define the Study Boundaries**

The disturbed area at the Big Chief – Golconda Mine site covers approximately 1.5 acres in the NE1/4 of the NW1/4 of Section 17, Township 7 North, Range 3 West, in Jefferson County, Montana.

### **Step 5: Develop a Decision Rule**

The potential receptors at the site include recreational users, terrestrial wildlife, vegetation, and aquatic life. Reclamation of the site will be necessary if levels of contaminants in surface and subsurface soil samples exceed the recreational cleanup levels and pose unacceptable risks to human health and the environment. Reclamation may include, but is not limited to, mine waste removal and reclamation-in-place actions.

### **Step 6: Specify Tolerable Limits on Decision Errors**

In general, environmental data may be strongly indicative of site conditions, but data are not absolutely definitive; therefore, decisions based upon the data could be in error. This is known as the decision error. This section discusses the limits on decision errors for this investigation.

Sampling error and measurement error are associated with environmental data collection and may lead to decision error. Sampling error occurs because it is impossible for a sampling effort to measure conditions at every point of a site or at every point in time. Sampling error occurs when the sample is not representative of the true state of the environment at a site. Measurement error occurs because of random and systematic errors associated with sample collection, handling, preparation, analysis, data reduction, and data handling. The two types of errors may lead to incorrect decisions or recommendations. In

general, decision errors are controlled by adopting a scientific approach that uses hypothesis testing to minimize the potential for decision errors. EPA guidance (1994) suggests the following steps to identify and control decision errors:

- Define the possible range of the parameter of interest,
- Define both types of decision errors and the consequences of each, and
- Specify a range of parameter values for which the consequences of decision errors are relatively minor.

Decision errors are evaluated through hypothesis testing. The reclamation may result in members of the public coming into contact with site wastes. Therefore, the null hypothesis for recreational use is that the site waste contains concentrations of contaminants above the risk-based recreation cleanup levels. The site may also have terrestrial wildlife, vegetation, and aquatic life that are exposed to site wastes and contaminated sediments and surface water runoff. Therefore, the null hypothesis for vegetation, terrestrial wildlife, and aquatic receptors is that site wastes materials, sediments, and surface water runoff are contaminated.

There are two types of decision errors:

**False Negative Error.** A false negative decision error occurs when the hypothesis is rejected although it is true. In the case of this project, the decision-maker would determine that the site does not contain mineral processing wastes, soil, surface water, sediment, or groundwater that require additional reclamation although concentration levels do require additional reclamation. The consequences of a false negative error would be that contaminated soil and groundwater are left in place instead of being reclaimed.

**False Positive Error.** A false positive decision error occurs when the hypothesis is not rejected although it is false. In the case of this project, the decision-maker would determine that the site contains mineral processing wastes, soil, surface water, sediment, and groundwater that require reclamation (based on the results of the analytical data), although the concentrations of contaminants in the wastes, soil, surface water, sediment, or groundwater do not require reclamation. The consequences of a false positive error would be that unnecessary resources may be spent to perform additional reclamation to address contamination that does not exist at levels exceeding action levels or acceptable risk levels.

Limits on decision errors due to sampling error will be minimized by using the analytical results from the site inspection and hazardous materials inventory (DEQ-MWCB 2004), other previously collected and reported data from the site (DEQ) and visual observations to identify contaminated areas. The sampling approach will be to collect enough data to define the areal and vertical extent of contamination.

## **Step 7: Optimize the Design**

The collection of surface soil and subsurface soil samples should be adequate to accept or reject the null hypothesis for recreational exposure. Visual examination of the site together with incorporation of previous site analytical data will be used to bias the collection of samples. The analytical results will be used to locate and characterize the extent of contamination, risk assessment, and reclamation design.

The collection of surface water and sediment samples should be sufficient to accept or reject the null hypothesis for exposure of aquatic organisms

### **Data Type, Analytical Level, and Use**

Table 4-5 presents data quality objectives, including data analysis or measurement, location of that measurement, analytical method, analytical support level, sample media, and the data use.

The analytical support levels are the analytical options available to support data collection activities. There are five general levels that are distinguished by the types of technology, documentation use, and degree of sophistication, which are:

- Level V - Nonstandard methods. Analyses that may require method modification and development. Analyses performed by the EPA Contract Laboratory Program (CLP) under a Special Analytical Service (SAS) request are considered Level V.
- Level IV - EPA CLP Routine Analytical Service (RAS). This level is characterized by rigorous QA protocols and documentation and provides qualitative and quantitative analytical data. Some commercial laboratories provide this level of data.
- Level III - Laboratory analysis using methods other than EPA CLP RAS methods. This level is used primarily in support of engineering studies using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS without the CLP requirements for documentation.
- Level II - Field analysis. This level is characterized by the use of portable analytical instruments on site or in mobile laboratories stationed near the site.
- Level I - Field screening. This level is characterized by the use of portable instruments that can provide real-time data to assist in optimizing sampling point locations and for health and safety support.

Analytical levels to be implemented during the Big Chief – Golconda Mine site activities are Levels II, III, and IV.

**TABLE 4-5**  
**SUMMARY OF DATA QUALITY OBJECTIVES**  
**BIG CHIEF – GOLCONDA MINE SITE**

Analysis	Location	Analysis Method	Analytical Support Level	Media	Data Use
TAL Metals	Laboratory	EPA 6010b	IV	SS, SW, GW	SC, RA, RA, ED
Particle Size	Laboratory	Method D421 ASTM	III	SS	SC
Cation Exchange Capacity	Laboratory	Method 9080 SW-846	III	SS	SC
Complete and Partial Agricultural Analysis	Laboratory	MSA, Second Edition	III	SS	SC
Hardness	Laboratory	SM 2340B	III	SW, GW	SC, RA, EA, ED
Sulfate	Laboratory	Method 9038 SW-846	III	SW, GW	SC, RA, EA, ED
Chloride	Laboratory	Method 325.3 CAWW	III	SW, GW	SC, RA, EA, ED
Specific Conductivity, Temperature	Field	Manufacturer's Instructions	II	SW, GW	SC
pH, Eh, Dissolved Oxygen	Field	Manufacturer's Instructions	II	SW, GW	SC

Notes:

ASTM	American Society of Testing and Materials (ASTM 1985)
CAWW	Methods for Chemical Analysis of Water and Wastes (EPA 1983)
CLP	Contract Laboratory Procedures
EA	Evaluation of alternatives
ED	Engineering design
EPA	Environmental Protection Agency
GW	Groundwater
MSA	Methods of Soil Analysis Part 2: Chemical Methods (ASA 1996)
RA	Risk assessment
SC	Site characterization
SM	Standard Method
SOW	Statement of Work
SS	Soil or sediment
SW	Surface water
SW-846	Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (EPA 1996)
TAL	Target analyte list includes: Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, and Zn

### **4.3.2 Quality Assurance Objectives**

The overall QA objective for the Big Chief – Golconda Mine site RI is to produce well-documented data of known quality. Meeting this objective involves establishing and meeting goals for precision, accuracy, completeness, representativeness, comparability, and target reporting limits for the analytical methods. The quantitative and qualitative QA objectives are presented below.

If analytical data fail to meet the QA objectives described in this section, Tetra Tech EM Inc. will explain in the RI report why the data failed to meet the objectives (for example, because of matrix interferences), and will describe the limitations and usability of the data. The following corrective actions may be taken for data that do not meet QA objectives: (1) verify that the analytical measurement system was in control, (2) thoroughly check all calculations, (3) use data qualifiers, and (4) assuming a sufficient quantity of sample is available, reanalyze the affected samples, if authorized by the Montana DEQ Big Chief – Golconda Mine site project manager. Corrective actions for internal QA and quality control (QC) are presented in detail in Section 4.3.7.

The data precision, accuracy, and completeness requirements are listed in Table 4-6; Table 4-7 lists the target reporting limits (TRL) for all analytes of concern by each analytical method. Table 4-5 presents the specific analytical methods selected for determining the concentration of components in the identified matrices.

#### **Quantitative QA Objectives**

Quantitative QA objectives that will be evaluated for both the field and laboratory data include completeness, accuracy, precision, and method detection limits. The following sections discuss the calculation of each QA objective.

#### **Precision and Accuracy**

Precision and accuracy are indicators of data quality. Generally, precision is a measure of the variability of a group of measurements compared to their mean value. Laboratory analytical precision is estimated by calculating the relative percent difference (RPD) between the analytical results from the matrix spike (MS) and matrix spike duplicate (MSD) samples for low-level samples and laboratory duplicate samples for high-level samples.

**TABLE 4-6**

**PRECISION, ACCURACY, AND COMPLETENESS REQUIREMENTS  
BIG CHIEF – GOLCONDA MINE SITE**

<b>Analyte</b>	<b>Matrix</b>	<b>Precision</b>	<b>Accuracy</b>	<b>Completeness</b>
Metals	Soil Sediment	<35% RPD between homogenized sample aliquots	Calibration, LCS to CLP data validation functional guideline criteria Matrix Spike Recovery 75% to 125%	90%
	Water	<20% RPD between duplicate samples	Calibration, LCS to CLP data validation functional guideline criteria Matrix Spike Recovery 75% to 125%	90%
Particle Size	Soil	<35% RPD between homogenized sample aliquots	Method-specified calibration	90%
Cation Exchange Capacity	Soil	<35% RPD between homogenized sample aliquots	Method-specified calibration	90%
Hardness	Water	<20% RPD between duplicate samples	Method-specified calibration	90%
Sulfate	Water	<20% RPD between duplicate samples	Method-specified calibration	90%
Chloride	Water	<20% RPD between duplicate samples	Method-specified calibration	90%
Field Parameters	Water	<10% RPD between replicate measurements	Method-specified calibration	90%

Notes:

CLP    Contract Laboratory Program  
LCS    Laboratory check sample  
MS    Matrix spike  
MSD   Matrix spike duplicate  
RPD   Relative percent difference  
%    Percent  
<    Less than

**TABLE 4-7**

**TARGET REPORTING LIMITS FOR SOIL, SEDIMENT,  
AND WATER METAL ANALYSIS  
BIG CHIEF – GOLCONDA MINE SITE**

Analyte Type	Method	Analyte	Reporting Limit Soil (mg/kg)	Reporting Limit Water (µg/L)
TAL Metals	SW-846 6010B, 6020, and 7471	Antimony	10	40
		Arsenic	10	5
		Barium	10	5
		Cadmium	10	5
		Chromium	10	10
		Cobalt	10	10
		Copper	10	10
		Lead	10	5
		Manganese	10	30
		Mercury	0.01	5
		Nickel	10	10
		Silver	10	10
		Zinc	10	5

Notes:

µg/L

Micrograms per liter

mg/kg

Milligrams per kilogram

TAL

Target analyte list

SW-846

Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (EPA 1987)

The RPD between the analyte levels measured in the MS sample and MSD sample (or sample duplicates) will be calculated using the following equation.

$$RPD = \frac{|MS - MSD|}{0.5 (MS + MSD)} \times 100\%$$

Where:

RPD = Relative percent difference  
MS = Matrix spike  
MSD = Matrix spike duplicate

Accuracy is a measure of the bias in a measurement system. Sampling accuracy is assessed by analyzing field and equipment blanks. The blanks are used to determine if the ambient air, sample containers, or sample preservatives are contaminating the sample. Analytical accuracy for laboratory data is assessed by evaluating matrix spike sample percent recovery, instrument calibration data, and laboratory control sample results.

Accuracy will be estimated by calculating the percent recovery of laboratory MS samples using the following equation.

$$\%R = \frac{(C_j - C_o)}{C_t} \times 100\%$$

Where:

%R = Percent recovery  
C<sub>j</sub> = Measured concentration in spiked sample aliquot  
C<sub>o</sub> = Measured concentration in unspiked sample aliquot  
C<sub>t</sub> = Actual concentration of spike added

Precision and accuracy goals depend on the types of samples and analysis to be performed and the ultimate use of the analytical data.

## **Completeness**

Completeness is defined as an assessment of the amount of valid analytical data obtained from a measurement system compared to the amount of analytical data needed to achieve a particular statistical level of confidence. The percent completeness is calculated by dividing the number of samples with

acceptable data by the total number of samples planned to be collected, and multiplying the result by 100. For this project, the QA objective for degree of completeness for the laboratory is 90 percent. If completeness is less than 90 percent, Tetra Tech EM Inc. will provide documentation explaining why this objective was not met, and the impact, if any, of a lower percentage on the project. Completeness will be reported as the percentage of all measurements judged valid. The following equation will be used to determine completeness:

$$\%C = (V/T) \times 100\%$$

Where:

%C	=	Percent completeness
V	=	Number of measurements judged valid
T	=	Total number of measurements

The completeness target for this project is 90 percent.

### **Target Reporting Limits**

The analytical measurements are listed in Table 4-5. The target reporting limits (TRL) for soil and water metals analyses are listed in Table 4-7. The target reporting limit is defined as the lowest concentration that needs to be reported for undiluted samples to obtain project objectives. The laboratory will try to achieve the lowest reporting limits possible for all measurements and will notify the Tetra Tech EM Inc. project manager if the detection limits for the samples exceed the TRLs. If samples are diluted to qualify constituents present at high concentration levels or to reduce matrix interferences, the reporting limit will be calculated as the reporting limit for the particular matrix multiplied by the dilution factor. The actual matrix reporting limits for each sample will vary depending on the concentration of analytes present and the presence of any interference.

### **Qualitative QA Objectives**

Qualitative QA objectives that will be evaluated include sample representativeness and comparability. The following sections present an analysis of the representativeness and comparability for each matrix to be sampled.

## **Representativeness**

Representativeness is the degree to which sample data represent characteristics of a population, variation at a sample point, or an environmental condition. Sampling locations will be selected to obtain representative soil and groundwater samples. Representative data will also be obtained through the proper collection and handling of samples. The QA objective is to obtain a statistically adequate number of samples that represent the various process matrices at the time samples are collected. The FSP contains a discussion of the representativeness of samples from each environmental matrix.

## **Comparability**

Comparability expresses the confidence with which one data set can be compared to another. Comparability will be maximized by using standard EPA methods and standard sampling techniques. Tetra Tech EM Inc. will document all sample locations, conditions, and field sampling methods. All results will be reported in standard units or, for field parameters, as defined in the method. All laboratory calibrations will be performed with standards traceable to the National Institute for Standards and Technology or to EPA-approved sources.

### **4.3.3 QA Sample Collection Procedures**

Various types of QA/QC samples will be collected during the field investigation activities: MS, MSD, and laboratory sample duplicates.

#### **MS, MSD, and Duplicate Samples**

The RI field team will collect MS, MSD, and duplicate samples at a rate of 1 for every 20 samples collected. If fewer than 20 samples are collected in one day, then a minimum of one set of field duplicate samples will be collected. For water samples requiring MS/MSD analyses, three times the amount of sample required for routine analysis will be collected. Soil samples do not require the collection of additional sample volume. In the laboratory, two (for MS/MSD) aliquots of this sample will be spiked to allow determination of percent recoveries and RPD for the MS compounds. MS/MSD samples will be collected for each matrix and each analytical method at a rate of 1 per 20 samples.

#### **4.3.4 Sample Documentation and Custody**

The possession and handling of each sample will be properly documented to promote timely, correct, and complete analysis for all required parameters. To promote sample integrity, each sample will be traceable from the point of collection through analysis and final disposition. Sample documentation and custody procedures are presented in Section 4.2.7.

#### **4.3.5 Equipment Operation, Maintenance, Calibration, and Standardization**

The procedures and frequency for field instrument operation, initial and continuing calibration verification, and maintenance requirements are described in the analytical methods or instrument manufacturer's calibration procedures. Calibration data will be recorded in the field logbook as will the source and method of preparation of the standard solutions used. Tetra Tech EM Inc. will calibrate all field analytical equipment before it is shipped to the field, and daily, before and after use. All calibration standards will be prepared from commercially available (Supelco or equivalent) NIST, EPA-traceable, or EPA-certified standards. The laboratory instrument operation, calibration, and maintenance procedures are described in the analytical method.

#### **4.3.6 Analytical Procedures**

The field and laboratory analytical methods that will be used are listed in Table 4-5. Laboratory analysis of samples collected during the RI will be completed by laboratories that have established QA protocols that meet or exceed EPA guidelines. EPA methods will be used whenever they are available for the target analyte.

#### **4.3.7 Data Reduction, Validation, and Reporting**

Procedures must be used to ensure that all laboratory data generated and processed are scientifically valid, defensible, and comparable. The following sections describe the data reduction, validation, and reporting procedures that will be used in this RI.

## **Data Reduction**

The results will be reported in milligrams per kilogram (mg/kg) for soil and sediment analysis and micrograms per liter (µg/L) for water analysis or using the procedures described in the analytical methods. In accordance with standard document control procedures, the laboratories will maintain on file the original copies of all data sheets and logbooks containing raw data, signed and dated by the responsible analyst. Separate instrument logs will also be maintained by the laboratories to enable a reconstruction of the run sequences for individual instruments. The laboratories will maintain all data on file in a secure archive warehouse accessible only to designated laboratory personnel. After three years, the laboratories will send all data on file to the Montana DEQ. The data will be disposed of only upon receipt of instructions to do so from Montana DEQ.

The laboratories will store all residual samples until disposal is authorized by the Montana DEQ. The laboratories will be notified within six months from the time of analysis of the disposition of residual samples. For the first 60 days after the laboratory receives the samples, samples and sample extracts will be stored in a refrigerator at 4°C. After that time, they may be stored at room temperature.

## **Data Validation**

Individual analysts will verify that the appropriate data forms have been completed and the completeness and correctness of data acquisition and reduction. The laboratory group leader will review calculations daily and inspect laboratory notebooks and data sheets weekly to verify accuracy, completeness, and adherence to the specified analytical method protocols. Calibration and QC data will be examined daily by the individual analysts and the laboratory supervisor. The group leader and QA manager or designee will verify that all instrument systems are in control and that QA objectives for precision, accuracy, completeness, and TRLs are being met.

Analytical outlier data are defined as QC data lying outside a specific QA objective range for precision or accuracy for a given analytical method. If QC data are outside control limits, corrective action procedures will be applied to determine the probable causes of the problem. If necessary, the sample will be reanalyzed, and only the reanalyzed results reported. If the problem is with the matrix, both initial and reanalyzed results will be reported and identified in the laboratory report. If reanalysis is not feasible, the initial analysis results will be reported and the results will be flagged and identified in the laboratory report.

Project outlier data are defined as sample data that are outside specified acceptance limits established around the central tendency estimator (the arithmetic mean) of the entire data set for the project. For data that are known or assumed to be normally distributed, the specified acceptance limits will be the 90 percent confidence limits defined by the Student one-tailed t-test distribution. Tetra Tech EM Inc. will identify project outlier data, which will be reported in the final laboratory report.

The laboratory project manager and QA coordinator will be responsible for laboratory data validation. The Tetra Tech EM Inc. project manager and Tetra Tech EM Inc. QA manager will be responsible for post-laboratory data validation of all data generated by the selected laboratories. The soil, sediment, and water metal data will be validated using the procedures described in Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analysis (EPA 1988).

### **Reporting**

A flow chart depicting the overall data handling and reporting scheme is given in Figure 4-2. Data will be reported in standard units as described in the analytical methods.

The laboratory project manager will be responsible for reviewing the laboratory report. The completed laboratory report will be approved by the laboratory project manager. The laboratory will provide all raw data necessary to fully validate the data. Each data package will include the following items:

- Case narrative including a statement of samples received, description of any deviation from standard procedures, explanation of any data qualifiers used, and any problems encountered during analysis
- A QC summary report including applicable surrogate recoveries, MS/MSD, recoveries, method blank results, and laboratory control sample recoveries. This report must identify all QC outliers and describe their impact on data quality and useability
- Chain-of-custody records
- Reporting limits
- Analytical instrument run logs
- Analytical instrument raw data for samples, blanks, and standards
- Initial calibration information
- Continuing calibration information
- Laboratory accuracy and precision limits
- All values below reporting limits and above method detection limits
- Date of analysis

**Figure 4-2      DATA REDUCTION, VALIDATION, AND REPORTING SCHEME**

The final report will contain a QA/QC summary that discusses whether the final data meet the original project QA objectives. If the QA objectives are not met, the report will contain an explanation of the impact on the evaluation of the project objectives.

#### **4.3.8 Corrective Action Procedures**

Corrective actions will be taken when any problems are identified in the program that affects product quality. The laboratory project manager and the Tetra Tech EM Inc. project manager, or their designees, are responsible for identifying the causes of the problems and developing a solution.

The cause of the problem must first be determined so that the effect of the problem on the overall program can be identified. The field team (and if necessary, the Montana DEQ project manager) will then develop a plausible corrective action. The effects of the action will be examined to determine whether the problem is addressed.

If the corrective action is initially successful, the laboratory project manager, or designee, will prepare a corrective action memorandum describing the corrective action, how and when it will be implemented, and the expected results. A copy of the memorandum will be sent to the Tetra Tech EM Inc. project manager and QA manager and then to the Montana DEQ project manager. The laboratory project manager, or designee, will be responsible for implementing the corrective action and assessing its effectiveness. Procedures are presented below for correcting (1) problems detected during audits, (2) laboratory problems, and (3) data outside control limits.

#### **Performance and System Audits**

The Tetra Tech EM Inc. program manager and QA manager will perform an internal QA audit of field procedures. If problems are detected during any field audit, the following procedures will be followed:

- The field team leader will immediately notify the field or laboratory personnel responsible, the Tetra Tech EM Inc. project manager, the Tetra Tech EM Inc. QA manager, and all other appropriate personnel of the problem and any corrective action to be taken.
- Personnel will then correct the problem according to the procedures outlined above.

### **Laboratory Corrective Actions**

The laboratory QA manager will review laboratory procedures to identify conditions or procedures that may have an adverse impact on data quality. The QA manager will then assess the impact on the quality of the associated data, and then identify the corrective actions to be implemented. All conditions or procedures that may have an adverse impact on data quality will be included in the laboratory reports.

### **Data Outside Control Limits**

The manner in which data outside of control limits are handled will depend on where the nonconformance is discovered. During data review in the laboratory, if QC checks fail to meet acceptance criteria, either the data will be flagged in accordance with standard EPA-defined data flags, or the nonconformance will be discussed in the case narrative. During the post-laboratory data validation, the data will be reviewed and assigned to one of the following three categories:

1. **Valid-unqualified** - This category is used for all data that meet all QC criteria without any qualifier. These data are useful for any purpose, and are not flagged.
2. **Valid-qualified** - Data placed in this category are valid, but their usefulness may be limited in certain situations. These data may be qualified as "estimated," which is indicated by use of a "J" flag, or by the use of a specific flag that conveys information about the limitations of the data.
3. **Invalid or Rejected** - Data are considered to be invalid in cases such as failure to properly ice samples that require storage at 4°C during shipment. These data are flagged with an "R" and are considered to be unusable for any purpose.

Data will be validated using EPA guidance documents and the specific requirements of this QAPP. If certain data appear to be borderline between two categories, the data validator may seek the advice of the individuals cited in Section 1.3.1 as having a QA function.

## **4.4 LABORATORY ANALYTICAL PLAN**

This LAP describes laboratory requirements for conducting the RI at the Big Chief – Golconda Mine site. Analysis of the solid matrix samples (surface soils, subsurface soils, and sediments), surface water, and groundwater samples will be conducted during the RI. All analytical work is to follow the requirements listed in this LAP for the duration of the project. This LAP contains four sections including sample collection requirements, laboratory requirements, quality assurance requirements, and analytical methods.

#### **4.4.1 Sample Collection Requirements**

Samples will be collected from surface soils, subsurface soils, sediments, surface water, and groundwater at the Big Chief – Golconda Mine site. The number and type of samples are specified in Table 4-3 (Section 4.2.1).

The matrix, analyte, required preservation, holding time, sample size, and containers to be used during the Big Chief – Golconda Mine site RI are specified in Table 4-5 (Section 4.2.8 of the FSP). Whenever possible, standard EPA protocols will be used.

#### **4.4.2 Laboratory Requirements**

The primary laboratory will be subcontracted by Montana DEQ for all total metals, particle size (texture), CEC, and agricultural analyses. The primary laboratory may use a separate laboratory for certain physical and chemical analyses. All laboratories for the project will be supplied with this document and will be required to meet the baseline data quality requirements for the project. All analyses performed by the project laboratories should follow the analytical methods listed in Table 4-8, which includes the applicable reference for each method.

#### **Qualifications and Experience**

The laboratory shall designate and use key personnel meeting the minimum requirements, as specified below, and comply with all terms and conditions of the contract. Experience is defined as more than 50 percent of the person's productive work time in active participation on a given task and includes the following:

1. The Inductively Coupled Plasma (ICP) emission spectroscopist responsible for work under this contract must have at least one year of experience in the operation of the ICP on soil and water samples.
2. The Furnace Atomic Absorption (AA) spectroscopist responsible for the work on this contract must have at least one year of experience in the operation of a furnace AA on soil and water.
3. The Hydride Generation AA and Cold Vapor AA (CVAA) spectroscopist responsible for work on this contract must have specific training in hydride applications and at least one year of experience in the operation of hydride AA and CVAA.

4. The inorganic sample preparation expert performing sample preparation for this contract must have at least three months of experience in the preparation of environmental samples for ICP and AA analysis.
5. The analyst or technician responsible for determining soil pH on the contract must have at least six months of experience in the technique and instrumentation.
6. The sample custodian, who is responsible for receiving, logging, and tracking the samples for the laboratory must have at least three months experience. This requirement is necessary because of the large number of samples and complexity of the project.

**TABLE 4-8**

**SUMMARY OF ANALYSES AND ANALYTICAL METHODS  
BIG CHIEF – GOLCONDA MINE SITE**

Analysis	Analytical Method	Media
TAL Metals	EPA 6010b	SS, SW, GW
Particle Size	Method D421 ASTM	SS
Cation Exchange Capacity	Method 9080 SW-846	SS
Complete and Partial Agricultural Analysis	MSA, Second Edition	SS
Hardness	SM 2340B	SW, GW
Sulfate	Method 9038 SW-846	SW, GW
Chloride	Method 325.3 CAWW	SW, GW
Specific Conductivity, Temperature	Manufacturer's Instructions	SW, GW
pH, Eh, Dissolved Oxygen	Manufacturer's Instructions	SW, GW

Notes:

SS	Soil or sediment
SW	Surface water
GW	Groundwater
TAL	Target analyte list includes: Ag, As, Au, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Se, Zn
CAWW	Methods for Chemical Analysis of Water and Wastes (EPA 1983)
SM	Standard Method
SW-846	Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, SW-846 (EPA 1987)
MSA	Methods of Soil Analysis Part 2: Chemical and Microbiological Prop. (ASA 1982)
CLP	Contract Laboratory Procedures
SOW	Statement of Work
EPA	Environmental Protection Agency
ASTM	American Society of Testing and Materials (ASTM 1985)

The laboratory shall have in place an acceptable QA plan. The plan shall designate key QA individuals by name and shall define their responsibilities. The plan shall detail the mechanisms for checking whether laboratory procedures are within control, and shall detail the corrective actions and responsibilities for out-of-control conditions.

### **Subcontracting**

Subcontracting portions of this work by the primary laboratory is acceptable for special analysis, but subcontracting must be approved by the Montana DEQ Big Chief – Golconda Mine site project manager, Mr. Dale Herbort. All laboratories in this project must abide by the LAP and the QAPP.

### **Confidentiality**

Analytical results are to be held in the strictest of confidence and will be discussed with only those individuals approved by the Montana DEQ Big Chief – Golconda Mine site project manager.

### **Reporting Times**

Analytical results are to be reported within 30 working days of sample receipt by the laboratory. If at all possible, holding, analysis, and reporting times should be minimized.

### **Reporting Format**

The data report package for the target analyte list (TAL) metals will not initially include a standard EPA Contract Laboratory Program (CLP) package, but the laboratory must save all the run data on magnetic media in order to generate a CLP package on request for a period of two years following completion of the analysis. The laboratory should obtain written permission from the Montana DEQ prior to disposing of any archived data support packages.

The data support package provided as a deliverable should include the following:

1. Cover letter documenting analytical protocols used.
2. Copies of completed chain-of-custody forms.
3. Cross-reference table of contractor and laboratory identification numbers.

4. Data summary tables (hard copy and electronic media in format to be negotiated between Tetra Tech EM Inc. and the laboratory.
5. QA/QC summaries including laboratory control samples (LCS), spikes, duplicates, and preparation blank results.

The physical parameters and other specialized chemical analyses, such as particle size, cation exchange capacity (CEC), and fertilizer and lime requirements, should comply with the above five components, when applicable.

### **Report Transmittal**

All data reports are to be sent directly to Tetra Tech EM Inc., Power Block Building, 7 West 6<sup>th</sup> Avenue, Suite 612, Helena, Montana 59601, in care of Mr. J. Edward Surbrugg.

#### **4.4.3 Quality Assurance Requirements**

The mechanism used to monitor the precision and accuracy of environmental data is the analysis of field and laboratory QC samples. The required field QC types and frequency are provided in the QAPP. The required laboratory QC requirements are specified in this LAP when the CLP statement of work (SOW) for inorganics (EPA 1992), or the analytical method does not define the QC requirement. Laboratory QC includes method blanks, duplicates, matrix spikes, and LCS. These QC requirements are to be performed at a frequency of 1 per 20 samples except for particle size analysis, components of the lime requirement, and CEC. The CEC will only have duplicates performed. The ranges for precision (duplicates) and accuracy (matrix spikes) acceptability are presented in the QAPP. The method blank should have a reported value within the method detection limit of the instrument detection limit.

Calibration procedures and sample preparation procedures are presented in the analytical method references listed in Table 4-8 when appropriate. There will be no referee laboratory or auditing of the main laboratory or the specialized laboratory (if applicable) for this project.

#### **4.4.4 Analytical Methods**

Analytical methods are summarized in Table 4-8 with the appropriate reference document(s). The project laboratories should contact Mr. Dale Herbort or Mr. Reynolds for permission to deviate from the listed analytical methods for the project analyses.

### **Detection Limits**

The instrumentation used must be sensitive enough to meet the required detection limits. Instruments for target analyte analyses are ICP, AA, and CVAA. The detection limits for the parameters presented in Tables 4-4 (Section 4.2.8) and 4-8 are included in the analytic reference methods.

### **Storage Requirements**

The contracted laboratory is required to have a secured sample bank for storage of samples, digestates, and extracts. Original samples will be stored in the sample bank for a standard six month interval. All other forms of the sample to be analyzed will be stored in this area for the standard six month interval after analysis or to the end of the analyte holding time, whichever comes first. This will provide the Montana DEQ and Tetra Tech EM Inc. ample time to review data and request reanalysis if necessary. At the end of six months time, the laboratory will be responsible for sample disposal.

### **Chain-Of-Custody**

A sample is physical evidence collected from a facility or from the environment. An essential part of hazardous waste investigations is that samples and data may be used as evidence in legal proceedings. Laboratories performing analyses will use document control and chain-of-custody procedures as specified in Exhibit F for the CLP SOW for inorganics (EPA 1992).

### **Sample Stream**

In accordance with EPA procedures, field QC samples (duplicates, blanks, and equipment rinsates) will be treated in the same manner as the natural samples. This provides external QC checks of laboratory data.

## **4.5 HEALTH AND SAFETY PLAN**

The health and safety plan for RI activities at the Big Chief – Golconda Mine site begins on the next page.

## HEALTH AND SAFETY PLAN

<b>Site Name:</b> BIG CHIEF – GOLCONDA MINE SITE	<b>Site Contact:</b> J. Edward Surbrugg, Tetra Tech EM Inc.	<b>Telephone:</b> (406) 442-5588
<b>Location:</b> Southeast of Helena, Montana	<b>Client Contact:</b> Dale Herbort, MWCB	<b>Telephone:</b> (406) 841-5028
<b>EPA I.D. No.:</b> Not Applicable	<b>Prepared By:</b> Jessica Allewalt, Tetra Tech EM Inc.	<b>Date:</b> 03/25/05
<b>Project No.</b> S1129-30SMLSRI	<b>Date of Proposed Activities:</b> April-May 2005	
<div style="display: flex; justify-content: space-between;"> <div style="width: 40%;"> <p><b>Objectives:</b> The Big Chief – Golconda Mine site is an abandoned lead and zinc mine site located southwest of Jefferson City, MT. The site contains several waste piles and regraded areas and is used for recreational purposes. The Montana DEQ/MWCB is currently preparing plans for mitigating environmental impacts associated with the waste rock and contaminated soils and sediments on this site.</p> </div> <div style="width: 58%;"> <p><b>Site Type:</b> <i>Check as many as applicable.</i></p> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 33%;"><input type="checkbox"/> Active</div> <div style="width: 33%;"><input type="checkbox"/> Confined space</div> <div style="width: 33%;"><input type="checkbox"/> Well field</div> <div style="width: 33%;"><input checked="" type="checkbox"/> Inactive</div> <div style="width: 33%;"><input type="checkbox"/> Landfill</div> <div style="width: 33%;"><input type="checkbox"/> Unknown</div> <div style="width: 33%;"><input type="checkbox"/> Secure</div> <div style="width: 33%;"><input checked="" type="checkbox"/> Uncontrolled</div> <div style="width: 33%;"><input type="checkbox"/> Underground storage tank</div> <div style="width: 33%;"><input checked="" type="checkbox"/> Unsecure</div> <div style="width: 33%;"><input type="checkbox"/> Industrial</div> <div style="width: 33%;"><input checked="" type="checkbox"/> Other (<i>specify</i>) <u>Abandoned mine site</u></div> </div> </div> </div>		
<p><b>Site Description and History:</b></p> <p>The Big Chief-Golconda Mine is situated in the Elkhorn Mountains approximately 12 miles southeast of Helena, Montana at an elevation of approximately 4,980 feet above mean sea level (amsl) in Section 17, Township 7 North, Range 3 West, Montana principle meridian (Latitude North 46.3586°; Longitude West 112.01° ). The Big Chief-Golconda Mine site is comprised of approximately 1.5 acres of mining impacted land and was a historic producer of lead and zinc. The site is bordered to the east by Golconda Creek.</p>		

Note: A site map is provided on Page 4-50. Definitions and additional information about this form are provided on Page 4-49.

# HEALTH AND SAFETY PLAN

## Waste Management Practices:

Tetra Tech EM Inc. investigated the Big Chief – Golconda Mine site in 2004 in order to complete a site inspection and hazardous materials inventory (DEQ-MWCB 2004). The volume of waste rock associated with the Big Chief – Golconda Mine site was estimated at 5,000 cubic yards.

Analysis of solid-matrix samples collected during the inventory indicates that the waste rock contains elevated concentrations of arsenic (up to 153 milligrams per kilogram [mg/kg]), lead (up to 32,300 mg/kg), and manganese (up to 4,630 mg/kg).

## Waste Types:

☐ Liquid

☒ Solid

☐ Sludge

☐ Gas

☐ Unknown

☐ Tailings

## Waste Characteristics:

☐ Corrosive

☒ Toxic

☐ Inert

☐ Ignitable

☐ Flammable

☐ Volatile

☐ Reactive

☐ Radioactive

☐ Unknown

☐ Other (specify) \_\_\_\_\_

## Hazards of Concern:

☒ Heat stress

☒ Cold stress

☐ Explosion or fire hazard

☐ Oxygen deficiency

☐ Radiological hazard

☐ Underground storage tanks

☐ Surface tanks

☒ Buried utilities

☒ Overhead utilities

☐ Biological hazard

☐ Noise

☒ Inorganic chemicals

☐ Organic chemicals

☒ Heavy equipment

☒ Other (specify) Wood and metal debris, steep slopes, and loose rock and soil

## Explosion or Fire Potential:

☐ High

☐ Medium

☒ Low

☐ Unknown

## HEALTH AND SAFETY PLAN

**Chemical Products Tetra Tech EM Inc. Will Use or Store On Site:** (Attach a Material Safety Data Sheet [MSDS] for each item.)

☒ Alconox® or Liquinox®

☐ Hydrochloric acid (HCl)

☒ Nitric Acid (HNO<sub>3</sub>)

☐ Sodium hydroxide (NaOH)

☒ Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

☐ Other (*specify*) \_\_\_\_\_

## HEALTH AND SAFETY PLAN

Chemicals Present at Site	Highest Observed Concentration (specify units and media)	PEL/TLV (specify ppm or mg/m <sup>3</sup> )	IDLH Level (specify ppm or mg/m <sup>3</sup> )	Symptoms and Effects of Acute Exposure	Photo-ionization Potential (eV)
Arsenic	153 mg/kg	0.01 mg/m <sup>3</sup>	5 mg/m <sup>3</sup>	Ulceration of nasal septum, dermatitis, gastrointestinal disturbances, peripheral neuropathy, respiratory irritation, hyperpigmentation of skin; potential occupational carcinogen	NA
Cadmium	68 mg/kg	0.005 mg/m <sup>3</sup>	9 mg/m <sup>3</sup>	Pulmonary edema, dyspnea, cough, chest tightness, substernal pain; headache; chills, muscular aches; nausea, vomiting, diarrhea; anosmia, emphysema, proteinuria, mild anemia, potential occupational carcinogen	NA
Chromium	8 mg/kg	1 mg/m <sup>3</sup>	250 mg/m <sup>3</sup>	Irritation of the eyes, skin, and lungs; fibrosis (histologic)	NA
Copper	883 mg/kg	1 mg/m <sup>3</sup>	100 mg/m <sup>3</sup>	Irritation of eyes, nose, pharynx; nasal perforation, metallic taste, dermatitis	NA
Lead	32,300 mg/kg	0.05 mg/m <sup>3</sup>	100 mg/m <sup>3</sup>	Weakness, lassitude, insomnia; facial pallor; pal eye, anorexia, low-weight, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; wrist and ankle paralysis; encephalopathy; nephropathy; irritation of eyes; hypotension	NA
Manganese	4,630 mg/kg	5 mg/m <sup>3</sup>	500 mg/m <sup>3</sup>	Parkinson's disease; asthenia, insomnia, mental confusion; metal fume fever; dry throat, cough, chest tightness, dyspnea, rales, flu-like fever; low-back pain; vomiting; malaise; fatigue; kidney damage	NA
Mercury	0.9 mg/kg	0.1 mg/m <sup>3</sup>	10 mg/m <sup>3</sup>	Cough, chest pain, dyspnea, bronchitis pneumonitis; tremor, insomnia; irritability, indecision; headache, fatigue, weakness; stomatitis, salivation, gastrointestinal disturbance, anorexia, low-weight; proteinuria; irritation of eyes and skin	NA
Zinc	12,300 mg/kg	5 mg/m <sup>3</sup>	500 mg/m <sup>3</sup>	Sweet, metallic taste; dry throat, cough; chills, fever; tight chest, dyspnea, rales, reduced pulmonary function; headache; blurred vision; muscle cramps, lower back pain; nausea, vomiting; fatigue, lassitude, malaise	NA
<b>Notes:</b>					
A = Air	GW = Groundwater	NA = Not available		ppm = Part per million	TLV = Threshold limit value
CARC = Carcinogenic	IDLH = Immediately dangerous to life or health	NE = Not established		S = Soil	U = Unknown
eV = Electron volt	mg/m <sup>3</sup> = Milligram per cubic meter	PEL = Permissible exposure limit		SW = Surface water	

## HEALTH AND SAFETY PLAN

<b>Field Activities Covered Under This Plan:</b>				
Task Description	Type	Level of Protection		Date of Activities
		Primary	Contingency	
1 Surface soil, sediment, and surface water sample collection.	<input checked="" type="checkbox"/> Intrusive <input type="checkbox"/> Nonintrusive	<input type="checkbox"/> C <input checked="" type="checkbox"/> D <input type="checkbox"/> Modified	<input type="checkbox"/> C <input checked="" type="checkbox"/> D <input checked="" type="checkbox"/> Modified	March-June 2005
2 Subsurface soil sample collection (test pits - backhoe).	<input checked="" type="checkbox"/> Intrusive <input type="checkbox"/> Nonintrusive	<input type="checkbox"/> C <input checked="" type="checkbox"/> D <input type="checkbox"/> Modified	<input type="checkbox"/> C <input checked="" type="checkbox"/> D <input checked="" type="checkbox"/> Modified	March-June 2005
<b>Site Personnel and Responsibilities (include subcontractors):</b>				
Employee Name and Office Code	TASK	Responsibilities		
J. Edward Surbrugg, Tetra Tech EM Inc. (HE)	All	Project Manager: Directs project investigation activities, makes site safety coordinator (SSC) aware of pertinent project developments and plans, and maintains communications with client as necessary.		
Chris Reynolds, Tetra Tech EM Inc. (HE)	All	Site Safety Coordinator (SSC): Ensures that appropriate personal protective equipment (PPE) is available, enforces proper utilization of PPE by on-site personnel, suspends investigative work if he or she believes that site personnel are or may be exposed to an immediate health hazard, implements the health and safety plan, and reports any observed deviations from anticipated conditions described in the health and safety plan to the health and safety representative.		
Joe Faubion, Tetra Tech EM Inc. (HE)	All	Field Team Leader, Project Engineer, and Field Personnel: Complete tasks as directed by the project manager, field team leader, and SSC and follow all procedures and guidelines established in the Tetra Tech, EM Inc. Health and Safety Manual.		
Gary Sturm, Tetra Tech EM Inc. (HE), Project Engineer	All			
Laura Newman, Tetra Tech EM Inc. (HE), Field Team Member	All			
Matt Hulbert, Tetra Tech EM Inc. (HE), Engineering Design Support	All			
Aaron Cade, Tetra Tech EM Inc. (HE), Technical Support, Site Map and Volume Estimates	All			
Jessica Allewalt, Tetra Tech EM Inc. (HE), Field Team Member	All			

# HEALTH AND SAFETY PLAN

<b>Protective Equipment:</b> (Indicate type or material as necessary for each task; attach additional sheets as necessary)			
Task: <input checked="" type="checkbox"/> 1 <input checked="" type="checkbox"/> 2 Level: <input type="checkbox"/> C <input checked="" type="checkbox"/> D <input type="checkbox"/> Modified <input checked="" type="checkbox"/> Primary <input type="checkbox"/> Contingency	Task: <input checked="" type="checkbox"/> 1 <input checked="" type="checkbox"/> 2 Level: <input type="checkbox"/> C <input checked="" type="checkbox"/> D <input checked="" type="checkbox"/> Modified <input type="checkbox"/> Primary <input checked="" type="checkbox"/> Contingency		
<b>RESPIRATORY</b> <input checked="" type="checkbox"/> Not needed <input type="checkbox"/> APR: _____ <input type="checkbox"/> Cartridge: _____ <input type="checkbox"/> Escape mask: _____ <input type="checkbox"/> Other: _____	<b>PROTECTIVE CLOTHING</b> <input checked="" type="checkbox"/> Not needed <input type="checkbox"/> Tyvek® coveralls: _____ <input type="checkbox"/> Saranex® coveralls: _____ <input type="checkbox"/> Coveralls: _____ <input type="checkbox"/> Other: _____		
<b>HEAD AND EYE</b> <input type="checkbox"/> Not needed <input checked="" type="checkbox"/> Safety glasses: <u>As Required</u> <input type="checkbox"/> Face shield: _____ <input type="checkbox"/> Goggles: _____ <input checked="" type="checkbox"/> Hard hat: <u>As Required</u> <input type="checkbox"/> Other: _____	<b>GLOVES</b> <input type="checkbox"/> Not needed <input checked="" type="checkbox"/> Undergloves: <u>Latex</u> <input checked="" type="checkbox"/> Gloves: <u>Leather</u> <input type="checkbox"/> Overgloves: _____		
<b>FIRST AID EQUIPMENT</b> <input type="checkbox"/> Not needed <input checked="" type="checkbox"/> Standard First Aid kit <input type="checkbox"/> Portable eyewash	<b>BOOTS</b> <input type="checkbox"/> Not needed <input checked="" type="checkbox"/> Work boots: <u>Steel-Toe/Steel Shank</u> <input type="checkbox"/> Overboots: _____		
<b>OTHER</b> <input type="checkbox"/> (specify): _____	<b>OTHER</b> <input type="checkbox"/> (specify): _____		

Note: APR = Air purifying respirator

# HEALTH AND SAFETY PLAN

<b>Monitoring Equipment:</b> (Specify instruments needed for each task; attach additional sheets as necessary)				
Instrument	Task	Instrument Reading	Action Guideline	Comments
Combustible gas indicator model:	<input type="checkbox"/> 1	0 to 10% LEL	No explosion hazard	<input checked="" type="checkbox"/> Not needed
	<input type="checkbox"/> 2	10 to 25% LEL > 25% LEL	Potential explosion hazard; notify SSC Explosion hazard; interrupt task; evacuate site, notify SSC	
O2 meter model:	<input type="checkbox"/> 1	> 23.5% O2	Potential fire hazard; evacuate site	<input checked="" type="checkbox"/> Not needed
	<input type="checkbox"/> 2	23.5 to 19.5% O2 < 19.5% O2	Oxygen level normal Oxygen deficiency; interrupt task; evacuate site; notify SSC	
Radiation survey meter model:	<input type="checkbox"/> 1	< 2 mrem per hour	Normal background	Note: Annual exposure not to exceed 1,250 mrem per quarter
	<input type="checkbox"/> 2	Three times background > 2 mrem per hour	Notify SSC Radiological hazard; interrupt task; evacuate site; notify SSC	
Photoionization detector model: <input type="checkbox"/> 11.7 eV <input type="checkbox"/> 10.2 eV <input type="checkbox"/> 9.8 eV <input type="checkbox"/> _____ eV	<input type="checkbox"/> 1	>0 to 5 ppm above background	Level D	<input checked="" type="checkbox"/> Not needed
	<input type="checkbox"/> 2	>5 to 20 ppm above background	Level C	
		>20 ppm above background	Evacuate site; notify SSC	
Flame ionization detector model:	<input type="checkbox"/> 1	>0 to 5 ppm above background	Level D	<input checked="" type="checkbox"/> Not needed
	<input type="checkbox"/> 2	>5 to 20 ppm above background >20 ppm above background	Level C Evacuate site; notify SSC	
Detector tubes models:	<input type="checkbox"/> 1 <input type="checkbox"/> 2	Specify:	Specify:	Note: This action level for upgrading the level of protection is one-half of the contaminant's PEL. If the PEL is reached, evacuate the site and notify the SSC.
Respirable dust monitor model:	<input type="checkbox"/> 1 <input type="checkbox"/> 2	Specify:	Specify:	<input checked="" type="checkbox"/> Not needed
Other: (specify):	<input type="checkbox"/> 1 <input type="checkbox"/> 2	Specify:	Specify:	<input type="checkbox"/> Not needed

Notes: eV = Electron volt

LEL = Lower explosive limit

mrem = Millirem

O<sub>2</sub> = Oxygen

PEL = Permissible exposure limit

ppm = Part per million

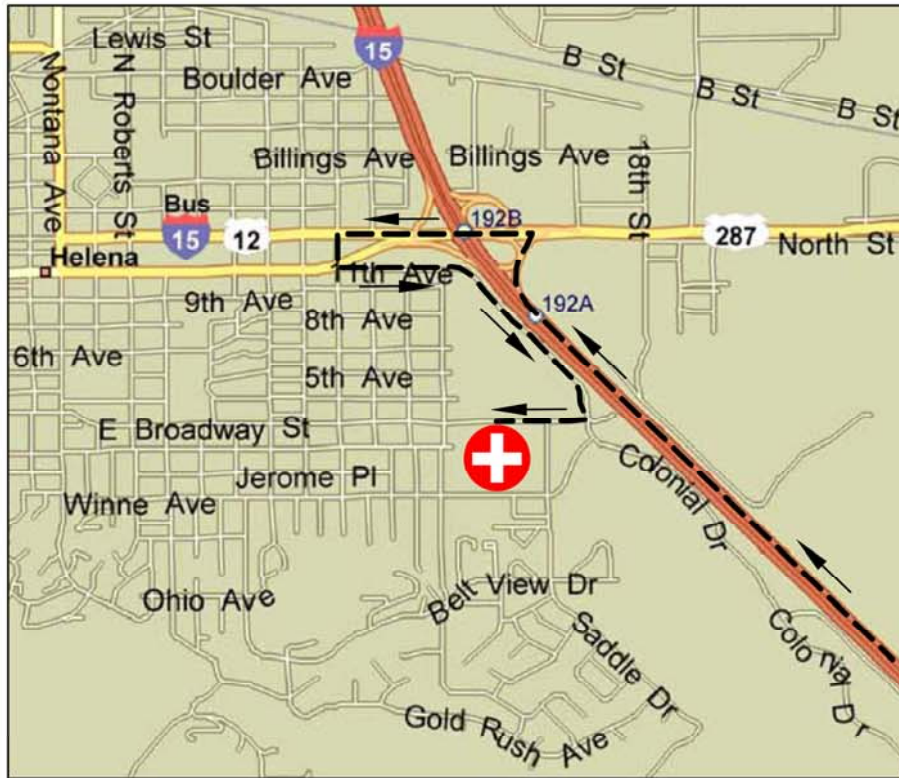
## HEALTH AND SAFETY PLAN

Additional Comments:	Emergency Contacts: <span style="float: right;">Telephone</span>
	U.S. Coast Guard National Response Center <span style="float: right;">800/424-8801</span> InfoTrac <span style="float: right;">800/535-5053</span> Fire department <span style="float: right;">911</span> Police department <span style="float: right;">911</span> Tetra Tech EM Inc. Personnel: Human Resource Development: Norman Endlich <span style="float: right;">703/390-0626</span> Health & Safety Representative: Judith Wagner <span style="float: right;">847/818-7192</span> Office Health and Safety Coordinator <span style="float: right;">442-5588</span> Project Manager <span style="float: right;">442-5588</span> Site Safety Coordinator <span style="float: right;">421-4549 (cell phone)</span>
Personnel Decontamination and Disposal Method:	Medical Emergency:
<p>Personnel will follow the U.S. Environmental Protection Agency's "Standard Operating Safety Guides" for decontamination procedures for Modified Level D personal protection (with Level D contingency). The following decontamination steps should be employed for this project:</p> <ul style="list-style-type: none"> <li>• Disposable gloves</li> <li>• Safety glasses and hard hat</li> <li>• Hand and face wash and rinse (portable water jugs and paper towels)</li> </ul> <p>If site conditions require upgrading to Level D, Tyvek coveralls, boot covers, and undergloves will be added to the standard PPE.</p> <p>All disposable equipment, clothing, and wash water will be double-bagged or containerized in an acceptable manner and disposed of in accordance with local regulations.</p>	<p>Hospital Name: <span style="float: right;">St. Peters Hospital</span></p> <p>Hospital Address: <span style="float: right;">2475 Broadway, Helena, MT 59601</span></p> <p>Hospital Telephone: <span style="float: right;">Emergency - 911 General – 442-2480</span></p> <p>Ambulance Telephone: <span style="float: right;">911 or 444-2228</span></p> <p>Route to Hospital: (see Page 4-50 for route map)</p> <p>Exit Big Chief – Golconda Mine site and head west to Jefferson City and the I-15 interchange; take I-15 north to Helena and take the first Helena exit from I-15 west onto Prospect Avenue; at second stop light turn left onto Fee Street and proceed straight through the stop light onto Colonial Drive; follow Colonial Drive to Broadway and turn right onto Broadway; St. Peters Hospital is located on the left.</p>

Note: This page must be posted on site.

# HEALTH AND SAFETY PLAN

Hospital Route Map:



# HEALTH AND SAFETY PLAN

## APPROVAL AND SIGN-OFF FORM

**Project No. S1129-06BLUERI**

*I have read, understood, and agree with the information set forth in this Health and Safety Plan and will follow the direction of the Site Safety Coordinator as well as procedures and guidelines established in the Tetra Tech, Inc., Health and Safety Manual. I understand the training and medical requirements for conducting field work and have met these requirements.*

_____ Name	_____ Signature	_____ Date
_____ Name	_____ Signature	_____ Date
_____ Name	_____ Signature	_____ Date
_____ Name	_____ Signature	_____ Date

APPROVALS: (Two Signatures Required)

_____ Site Safety Coordinator	_____ Date
_____ Health and Safety Representative or Designee	_____ Date

# HEALTH AND SAFETY PLAN

## DEFINITIONS

**Intrusive** - Work involving excavation to any depth, drilling, opening of monitoring wells, most sampling, and Geoprobe® work

**Nonintrusive** - Generally refers to site walk-throughs or field reconnaissance

### **Levels of Protection**

**Modified Level D** - Hard hat, safety boots, and glasses

**Level D** - Items listed for modified Level D above, **PLUS** protective clothing such as gloves, boot covers, and Tyvek® or Saranex® coveralls

**Modified Level C** - Hard hat, safety boots, glasses, and air purifying respirators with appropriate cartridges

**Level C** - Items listed for modified Level C above, **PLUS** protective clothing such as gloves, boot covers, and Tyvek® or Saranex® coveralls

### **Emergency Contacts**

**InfoTrac** - For issues related to incidents involving the transportation of hazardous chemicals; this hotline provides accident assistance 24 hours per day, 7 days per week

**U.S. Coast Guard National Response Center** - For issues related to spill containment, cleanup, and damage assessment; this hotline will direct spill information to the appropriate state or region

### **Health and Safety Plan Short Form**

- Used for field projects of limited duration and with relatively limited activities; may be filled in with handwritten text
- Limitations:
  - No Level B or A work
  - No more than two tasks
  - No confined space entry
  - No unexploded ordnance work

#### 4.6 REFERENCES CITED

- American Society of Agronomy. 1996. *Methods of Soil Analysis, Part 3, Chemical Methods*. Number 5 in the Soil Science Society of America Book Series, Madison, WI. 1390 p.
- American Society for Testing and Materials. 1985. *Standard Practice for Particle-Size Analysis and Determination of Soil Constants*.
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- Washington State Department of Ecology. 1997. Creation and Analysis of Freshwater Sediment Quality Values in Washington State. Publication No. 97-323a, Department of Ecology Publications Distributions Office, Olympia, Washington. July.

**RECLAMATION INVESTIGATION REPORT  
BIG CHIEF-GOLCONDA MINE SITE, JEFFERSON COUNTY, MONTANA**

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## **5.0 RECLAMATION INVESTIGATION**

As requested by the Montana DEQ/MWCB, TtEMI completed a reclamation investigation (RI) for the Big Chief-Golconda Mine Site. The RI delineates the nature and extent of wastes at the site, estimates risks these wastes may pose to human health and the environment, and presents data pertinent to potential reclamation.

### **5.1 INTRODUCTION**

The Big Chief-Golconda Mine Site is an abandoned hard rock mine listed on the Montana DEQ/MWCB priorities sites list. The Big Chief-Golconda Mine Site is located on the western edge of the Elkhorn Mountains 2 miles east of Jefferson City in the Colorado-Golconda Mining District in Jefferson County, Montana. The site is situated at an elevation of 4,980 feet above sea level and consists of 1.5 acres of lands contaminated by metal mining. It contains structures, waste rock dumps, and some scattered erosional remnants of waste rock piles along Golconda Creek.

The objectives of this RI report are to: (1) describe the field activities conducted at the site for the RI; (2) present observations and data collected during field activities for the RI; (3) interpret the results derived from the field activities as they pertain to the nature and extent of contamination; (4) address, as necessary, contaminant fate and transport and any perceived data gaps; and (5) summarize the human health and ecological risks associated with the site in its current state.

### **5.2 FIELD ACTIVITIES**

The field activities for the RI, conducted from September 14, 2004, to May 19, 2005, focused on collecting sufficient data to support the human health and ecological risk assessments and a detailed analysis of reclamation and land use alternatives. The analysis required to support the risk assessment, as described in the reclamation work plan (see Section 4), includes:

- Determining the magnitude and extent of contamination by metals from waste in the surface and subsurface
- Evaluating the magnitude and extent of sediment contamination
- Determining the magnitude of surface water contamination

- Determining the background concentrations of metals in soil

The following evaluations were also needed to support the detailed analysis of reclamation alternatives at the Big Chief-Golconda Mine Site:

- Developing accurate estimates of the area and volume of solid waste that requires reclamation
- Identifying reclamation requirements for disturbed areas, including liming requirements, solid matrix texture and grain size, fertilizer requirements, percent organic matter, and native plant species
- Identifying and characterizing potential repository sites
- Identifying potential borrow areas for clay, cover soil, and limestone

The following samples were collected at the Big Chief-Golconda Mine Site (summarized below in Table 501): (1) surface and subsurface site waste; (2) surface soil potentially contaminated with metals; (3) background soil; (4) potential borrow soil; (5) stream sediment; and (6) surface water.

The field activities for the RI are discussed below for the solid-matrix and surface water sampling efforts. Additional detailed information on the specific field sampling procedures used for this RI is described in the Big Chief-Golconda Site reclamation work plan (see Section 4) that contains the field sampling plan.

**TABLE 5-1**

**SOLID-MATRIX AND SURFACE WATER  
SAMPLE COLLECTION AND ANALYSIS  
BIG CHIEF-GOLCONDA MINE SITE**

Sample Type		Metals	Particle Size	Cation Exchange Capacity	Agronomic Analysis
Site Area	Surface	17	0	0	0
	Surface (Perimeter)	0	0	0	0
	Test Pit (Subsurface)	4	2	2	2
Background Soil	Surface	3	0	0	0
Stream Sediment	Surface	3	0	0	0
<b>Total Soil Samples</b>		<b>27</b>		<b>2</b>	<b>2</b>
Surface Water		3	0	0	0
<b>Total Soil and Water Samples</b>		<b>30</b>	<b>2</b>	<b>2</b>	<b>2</b>

### **5.2.1 Solid-Matrix Sampling**

The locations for the solid-matrix samples were selected to characterize wastes and the extent of elevated concentrations of metals at the Big Chief-Golconda Mine Site (see Figure 5-1). The sample locations were chosen based on various visible characteristics, including texture, staining, lack of vegetation, and topography. All samples of surface waste and soil were collected with a shovel from the 0- to 24-inch depth interval. Samples from vegetated areas were collected from the uppermost soil horizon.

Test pit samples were collected from the side of the excavated pit or with a trowel from the backhoe bucket. Test pits were installed to a maximum depth of 15 feet below ground surface (bgs), and samples were collected to depths up to 15 feet bgs. The deepest samples for most test pits were collected from the upper layer of what appeared to be buried native soil. Stream sediment samples were collected with a trowel from the bottom of the stream channel. Physical descriptions of the sample locations and materials sampled were recorded in a field logbook. A photocopy of the project field logbook is contained in Appendix A. Site photographs are presented in Appendix B.

A total of 27 solid-matrix samples were collected from the project area at the Big Chief-Golconda Site during the combined site inspection and RI field efforts. All solid-matrix samples were analyzed for metals at an off-site laboratory. Reclamation objectives were met by collecting two solid-matrix samples from native material underlying the waste rock dumps for analysis of particle size, and cation exchange capacity (CEC); in addition, samples underwent partial agronomic or agricultural analysis.

### **5.2.2 Surface Water Sampling**

Locations for surface water samples were selected to characterize the concentrations of metals in surface water (see Figure 5-1). Three surface water samples were collected from Golconda Creek upgradient and downgradient as well as in the center of disturbed areas. The water samples were collected by immersing the sample container into the stream. All sample containers were triple rinsed with sample water before the sample was collected. All surface water samples were sent to an off-site laboratory for analysis of total metals.

Figure 5-1      Site Map

### **5.3 SITE AND WASTE CHARACTERIZATION**

This section describes the waste characteristics and analytical results for the Big Chief-Golconda Mine Site, including the waste types, locations, volumes, physical properties, and results of off-site analysis for metals. This section also describes the results of samples collected to establish background concentrations in soil, stream sediment, and surface water. Characterization of the waste types is used to evaluate (1) the potential risk to human health and the environment, and (2) the final reclamation alternatives for the specific waste materials at the project site.

Solid-matrix samples were analyzed using EPA analytical method SW-846 6010. In addition, particle size, CEC, and partial agronomic analyses were completed (see Section 5.4). Surface water samples were analyzed for metals, common ions, and nitrates at an off-site laboratory. Appendix C contains the data quality and data validation report for off-site laboratory data. Complete analytical results are contained in Appendix D.

Evaluation of the data from the off-site laboratory indicated that the analytes detected that are useful for site characterization at the Big Chief-Golconda Mine Site are arsenic, copper, lead, manganese, and zinc.

Complete analytical results and laboratory reports for all metals are in Appendix D. The data presented in this section are compared with recreational cleanup levels for sites with maximum recreational use for abandoned sites (Tetra Tech 1996) and with screening levels for potentially phytotoxic concentrations of metals. The laboratory data are reported in units of milligrams per kilogram (mg/kg) and are directly comparable the residential and recreational cleanup guidelines (Tetra Tech 1996). The noncarcinogenic cleanup guideline using a 50-day goldpanner/rockhound exposure scenario for arsenic is 323 mg/kg, and the carcinogenic cleanup guideline at a  $10^{-4}$  risk level is 139 mg/kg. The cleanup guidelines using a 50-day goldpanner/rockhound exposure scenario for the other metals are 54,200 mg/kg for copper; 2,200 mg/kg for lead; 7,330 mg/kg for manganese; and 440,000 mg/kg for zinc.

#### **5.3.1 Site Solid Waste Materials**

The area at the Big Chief-Golconda Mine Site includes a large waste rock dump excavated from underground tunnels (now caved). A smaller waste rock dump with vegetation lies southeast of the main waste rock area and is the site of three structures. There is no evidence that any adits exist that are not caved. Several small piles of waste rock are also located east and west of Golconda Creek. No seeps are

evident emanating from beneath any of the larger waste rock piles. A shaft (caved) was at one time present at the top of the main waste rock dump and is now evidenced by a depression in the surface of the waste rock. Photographs of the site area are contained in Appendix B.

Soil samples BC-1 through BC-20 were collected from the site. Soil samples BC-1, BC-7, and BC-14 were collected beyond the visually identified edges of the waste rock and may be considered representative of background concentrations. Subsurface soil samples were collected from the large waste rock pile and from the small waste rock piles located along Golconda Creek. Two test pits (BIG-CRI-TP1 and BIG-CRI-TP2) were installed using a backhoe. The test pit soil samples were collected from waste rock piled at the site of the collapsed hoisting shaft, 100 feet west of Golconda Creek, and in waste rock next to the creek bank, which has been graded and vegetated. Test pit TP1 was excavated to a depth of 15 feet bgs, and test pit TP2 was excavated to 5 feet bgs to characterize the extent of contamination in the subsurface. Samples of waste rock and buried soils underlying the waste rock were collected from the test pits. Figure 5-1 shows the locations of the surface soil and test pit samples. Table 5-2 presents the concentrations of metals in surface soil and subsurface soil samples.

All solid matrix samples (BC-2 through BC-6, BC-8 through BC-12, TP1A, and TP1B) collected from waste rock at the upper waste rock dump contained lead (1,360 to 32,300 mg/kg) at concentrations above the residential cleanup guideline (400 mg/kg). Eight of these samples contained lead (2,450 to 32,300 mg/kg) at concentrations above the recreational cleanup guideline (2,200 mg/kg). The samples (BC-13 through BC-16, BC-18 through BC-20 and TP2A) collected from the waste rock along Golconda Creek contained lead (1,410 to 3,560 mg/kg) at concentrations greater than the residential cleanup guideline (400 mg/kg). Six of these samples contained lead (2,740 to 3,560 mg/kg) at concentrations above the recreational cleanup guideline (2,200 mg/kg). The concentrations of arsenic, copper, lead, manganese, and zinc were below the 50-day rockhound/goldpanner recreational cleanup guidelines in all surface soil samples. Twelve of the samples contained arsenic at concentrations greater than the DEQ action level (40 mg/kg).

The samples of waste rock with concentrations of lead that exceeded the recreational cleanup guideline were collected from the main mine dump and from several small piles along Golconda Creek. The majority of the waste rock on the site is bare of vegetation. A thin veneer of regraded soils on the waste

TABLE 5-2

**CONCENTRATIONS OF METALS IN SOLID MATRIX SAMPLES  
SITE INSPECTION AND RECLAMATION INVESTIGATION  
BIG CHIEF-GOLCONDA MINE SITE (mg/kg)**

Sample	Description	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Silver	Zinc
BC-1	Surface Soil	--	4	20	15,000	363	1,300	--	115
BC-2	Waste Rock	<b>153</b>	--	883	45,600	<b>32,300</b>	58	143	69
BC-3	Waste Rock	<b>55</b>	4	141	26,800	<b>3,750</b>	1,370	6	193
BC-4	Waste Rock	<b>46</b>	--	241	26,200	<b>5,500</b>	107	6	508
BC-5	Waste Rock	17	68	91	17,200	<b>1,360</b>	<b>3,240</b>	-	123
BC-6	Waste Rock	23	30	90	24,400	<b>1,670</b>	<b>4,630</b>	--	560
BC-7	Surface Soil	--	3	49	7,950	207	1,080	--	748
BC-8	Waste Rock	<b>90</b>	5	106	16,000	<b>5,710</b>	61	28	276
BC-9	Waste Rock	<b>83</b>	--	65	28,200	<b>3,730</b>	537	--	454
BC-10	Waste Rock	<b>56</b>	--	43	25,700	<b>2,450</b>	630	--	331
BC-11	Waste Rock	<b>43</b>	11	126	28,700	<b>7,630</b>	1,550	7	308
BC-12	Waste Rock	<b>50</b>	3	92	29,400	<b>2,810</b>	565	--	137
BC-13	Waste Rock	<b>63</b>	--	83	22,900	<b>3,220</b>	19	5	156
BC-14	Surface Soil	--	--	--	17,600	93	1,120	--	584
BC-15	Waste Rock	18	--	58	27,300	<b>1,410</b>	130	--	2,210
BC-16	Waste Rock	35	--	239	30,800	<b>3,340</b>	286	6	639
BC-17	Waste Rock	29	--	156	17,900	<b>3,560</b>	232	7	504
BC-18	Waste Rock	26	--	217	19,800	<b>2,640</b>	491	5	503
BC-19	Waste Rock	<b>44</b>	--	68	30,200	<b>3,140</b>	230	--	539
BC-20	Waste rock	<b>62</b>	--	42	33,500	<b>2,740</b>	338	--	574
TP1A	Waste rock	29	--	131	42,900	<b>1,650</b>	122	NA	NA
TP1B	Waste rock	32	5	137	47,900	<b>1,570</b>	<b>4,060</b>	NA	NA
TP2A	Waste rock	<b>60</b>	11	202	42,000	<b>5,920</b>	1,360	NA	NA
TP2B	Soil	16	5	138	43,100	<b>423</b>	1,670	NA	NA
Recreational Cleanup Guideline		323		54,200		2,200	7,330		440,000
Residential Cleanup Guideline		40		3,100		400	1,800		23,000

Notes:

**Bold**/shaded values exceed residential or recreational cleanup guidelines (Tetra Tech 1996).

-- Nondetect concentration

rock pile (under the pole barn) near the creek supports mature grass and forms part of the lawn surrounding the cabin. The volume of waste rock is estimated at 6,000 cubic yards (yd<sup>3</sup>). The volume of waste rock was estimated using analytical and field data and measured depths of waste rock.

### 5.3.2 Stream Sediment

The objectives of sampling the stream sediment were to characterize the extent of metals contamination in stream sediment associated with surface water at the Big Chief-Golconda Mine Site and to assess the potential for downstream migration of metals in sediments from the site. Three stream sediment samples were collected during the RI. Sediment sample SD-1 was collected upgradient of the disturbed area. Sample SD-2 was collected in the central area of disturbance, near erosional remnants of waste rock piles in the creek bed. Sediment sample SD-3 was collected downgradient of the main disturbed area. The sediment sample locations are shown on Figure 5-1.

All sediment samples were analyzed for metals at an off-site laboratory. Table 5-3 presents the concentrations of metals in stream sediment samples. Complete analytical results are contained in Appendix D.

**TABLE 5-3**  
**CONCENTRATIONS OF METALS IN SEDIMENT**  
**BIG CHIEF-GOLCONDA MINE SITE (mg/kg)**

Sample	Description	Arsenic	Copper	Lead	Manganese	Zinc
BC-SD-001	Upgradient	77	28	351	330	208
BC-SD-002	Mid Mine Area	52	27	794	298	211
BC-SD-003	Downgradient	72	26	388	430	243
Washington Dept. of Ecology Goals <sup>a</sup>		19	None	240	1,400	500

Note:

<sup>a</sup> Washington State Freshwater Sediment Quality Probable Apparent Effects Thresholds (PAETs) values (Washington State Department of Ecology 1997).

### 5.3.3 Background Soil

Three soil samples were collected to evaluate the ambient (background) concentration of metals in surface soils near the Big Chief-Golconda Mine Site. The sample collection locations are shown on Figure 5-1. The background soil samples were analyzed for metals at an off-site laboratory. Table 5-4 lists the concentrations of arsenic, copper, lead, manganese, and zinc for comparison with concentrations of metals in the study area. Complete analytical results are contained in Appendix D.

**TABLE 5-4**  
**BACKGROUND CONCENTRATIONS OF METALS IN SOIL**  
**BIG CHIEF-GOLCONDA MINE SITE (mg/kg)**

Sample	Description	Arsenic	Copper	Lead	Manganese	Zinc
BC-1		<10	20	363	1,300	762
BC-7		<10	49	207	1,080	847
BC-14		<10	<10	93	1,120	243
Mean Background Concentrations		<10	26	221	1,166	617
Recreational Cleanup Guideline		323	54,200	2,200	7,330	440,000
Residential Cleanup Guideline		40	3,100	400	1,800	23,000

Note:

Recreational cleanup guidelines based on 50-day goldpanner/rockhound exposure scenario (Tetra Tech 1996).

All metals were detected at concentrations below the recreational cleanup guidelines. The mean background concentrations measured by the off-site laboratory are shown in the table above.

Comparisons of the concentrations of metals indicate that concentrations of arsenic, lead, manganese, and zinc are elevated in the waste rock.

### 5.3.4 Surface Water

The following sections describe the concentrations of metals in surface water samples. Three surface water samples were collected from Golconda Creek during the RI (Table 5-5). Figure 5-1 shows the surface water sampling locations. Sample BC-SW-001 was collected upstream of the waste rock. Sample BC-SW-002 was collected in the area most affected by metal mining. Sample BC-SW-003 was collected downstream of the waste rock and area affected by mining.

**TABLE 5-5**  
**CONCENTRATIONS OF METALS IN SURFACE WATER**  
**BIG CHIEF-GOLCONDA MINE SITE (µg/L)**

Sample	Location	As	Cd	Cu	Fe	Pb	Mn	Zn
BC-SW-001	Upstream	<3	0.2	<1	70	<3	<5	30
BC-SW-002	Mid-mine area	<3	0.4	3	<b>770</b>	<b>19</b>	43	70
BC-SW-003	Downstream	<3	0.2	<1	90	4	<5	30
WQB-7 Human Health Standard (µg/L)		18	5	1,300	300 <sup>a</sup>	15	50 <sup>a</sup>	2,000
WQB-7 Chronic Aquatic Life Standard (µg/L)		150	0.16 <sup>b</sup>	5.2 <sup>b</sup>	1,000	3.2 <sup>c</sup>	--	67 <sup>b</sup>
Recreational Cleanup Guideline (µg/L)		153	256	18,900	1,000,000	220	2,560	153,000

Notes:

Bold/shaded values exceed WQB-7 human health water quality standards (DEQ 2001).

<sup>a</sup> Maximum contaminant levels (MCL) have been established for iron and manganese (300 and 50 µg/L), which are based on aesthetic properties such as taste, odor, and staining.

<sup>b</sup> Based on 50 mg/L hardness

<sup>c</sup> Based on 100 mg/L hardness

< Less than

µg/L Micrograms per liter

As = Arsenic    Cd = Cadmium    Cu = Copper    Fe = Iron    Pb = Lead    Mn = Manganese    Zn = Zinc

Surface water samples (BC-SW-001 upstream and BC-SW-003 downstream) collected from Golconda Creek did not contain metals at concentrations greater than the WQB-7 human health standard. Sample BC-SW-002, collected adjacent to the site, contained several metals at concentrations greater than the WQB-7 standard. All three surface water samples contained cadmium (0.2 to 0.4 micrograms per liter [ $\mu\text{g/L}$ ]) at concentrations above the WQB-7 chronic aquatic life standard (0.16  $\mu\text{g/L}$ ). Sample BC-SW-002 contained iron (770  $\mu\text{g/L}$ ) above the secondary maximum contaminant level (MCL) (300  $\mu\text{g/L}$ ); lead (19  $\mu\text{g/L}$ ) above the human health standard (15  $\mu\text{g/L}$ ) and chronic aquatic life standard (3.2  $\mu\text{g/L}$ ); and zinc (70  $\mu\text{g/L}$ ) above the chronic aquatic life standard (67  $\mu\text{g/L}$ ).

## **5.4 RECLAMATION AND LAND USE CHARACTERIZATION**

Physical and chemical characteristics of the soils and mining-related wastes associated with the Big Chief-Golconda Mine Site are needed to define the reclamation alternatives and the nature of contamination at the site. Visual observations indicate that large portions of the site are unvegetated (waste rock dumps), and analysis of the solid-matrix samples indicates that some metals (primarily arsenic, lead, and zinc) are likely present in the wastes at phytotoxic levels. However, other physical and chemical properties may also directly or indirectly affect the natural colonization of the area.

Additional information on reclamation is needed to quantify and evaluate (1) potential toxic and inhibitory properties (acid-base accounting and nutrients), and (2) the need for soil amendments to reclaim the materials in place (pH, particle size analysis, and CEC). Specific analytical results are used in selecting reclamation alternatives to measure the water-holding capacity of the waste materials and soil, the potential for phytotoxic concentrations of metals, the acid-generating capacity of the waste materials, and the type and amount of amendments (lime, organic matter, and others) that may be required to ameliorate toxic and inhibitory waste conditions. The agronomic analyses are important indicators of the nutrient availability to plants and the fertility potential in soils.

### **5.4.1 Particle Size Analysis**

Particle size analysis is a measurement of the size distribution of individual particles in a solid-matrix sample. Particle size distribution is used to characterize and evaluate soil texture, sedimentation and alluvial processes, structural and construction purposes, many basic soil science properties (shrink-swell, plasticity, and other properties), and to predict hydraulic properties such as water-holding capacity and unsaturated hydraulic conductivity. Several particle size classification systems are defined; the U.S.

Department of Agriculture (USDA) classification system is one of the most common and will be used in this RI report. The USDA classification system defines soil particles smaller than 2,000 micrometers ( $\mu\text{m}$ ) or microns into three major size groups:

- Sands (less than 2,000  $\mu\text{m}$  to 50  $\mu\text{m}$ ),
- Silts (less than 50  $\mu\text{m}$  to 2  $\mu\text{m}$ ),
- Clays (less than 2  $\mu\text{m}$ ).

Particle size was analyzed in two samples from the Big Chief-Golconda Mine Site; the results are listed in Table 5-6. The laboratory report is in Appendix D. The two subsurface soil samples were collected from true pedological soil horizons that were buried or otherwise affected by past mining.

**TABLE 5-6**  
**PARTICLE SIZE ANALYSIS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Sample ID Number	Waste Type	Particle Size Distribution		
		% Sand	% Silt	% Clay
BIG-CRI TP1B	Soil under Waste Rock	62.5	13.7	23.8
BIG-CRI TP2B	Soil under Waste Rock	75.0	12.5	12.5

The samples contained percentages of sand ranging from 62.5 percent (sample TP1B) to 75.0 percent (sample TP2B), percentages of silt from 12.5 percent (sample TP2B) to 13.7 percent (sample TP1B), and percentages of clay from 12.5 percent (sample TP2B) to 23.8 percent (sample TP1B). These sandy clay loam to sandy loam textured soils have an inherently lower amount of internal surface area and lower water-holding capacity. These coarse-textured soils tend to be lower in fertility and do not retain much soil nutrients for plant growth. Another characteristic of sandy soils is their potential for greater leaching of metals to underlying zones. Advantages of sandy soils are their inherent higher strength and capability for supporting construction across a wide moisture regime. These soil textures indicate that their genesis is from the Cretaceous Boulder batholith parent materials, as well as from mining-related pulverization of rock. The grain size distribution is similar in the general perimeter of the site.

#### 5.4.2 Cation Exchange Capacity

CEC is a measure of the quantity of readily exchangeable cations that can neutralize the negative charges in the waste materials or soil. In general, the internal surface area is larger and the CEC value is higher in soils with finer textures and higher percentages of clay. The negative charges are derived primarily from isomorphous substitution within clay minerals and broken bonds at the mineral edges and surfaces. Isomorphous substitution creates a permanent charge and is independent of the pH. The mineral edge charge, however, is variable and depends on pH and other properties.

CEC is used to evaluate the potential concentrations of plant-available metals that are readily exchangeable in the plant-growth media and that are potentially phytotoxic. CEC values in the coarse-textured wastes and soils associated with the Big Chief-Golconda Mine Site are lower than materials with finer textures (in other words, that contain more silt and clay). Typically, coarse-textured soils cannot retain high levels of exchangeable metals. The relatively small amount of clay in these materials is predominantly 1:1-type clay mineralogy. CEC values in clays with 1:1-type mineralogy are lower than in clay soils that contain more 2:1-type smectite clays. In addition, the organic matter content of a soil will have a large effect on its CEC.

Higher CEC values in soil are considered beneficial for fertility and plant growth when the exchange sites are occupied by plant macronutrients and micronutrients. However, higher CEC values in fine-textured wastes (for example, tailings) may be detrimental when the exchange sites are occupied by potentially phytotoxic metals.

CEC was analyzed in two samples from across the Big Chief-Golconda Mine Site. The results are presented in Table 5-7, and a copy of the laboratory report is in Appendix D. The CEC values of the two samples are below 20 milliequivalents per 100 grams (meq/100g). These CEC values are low but in a range expected for coarse grained (skeletal) soils developed from granite (Boulder batholith) materials. The CEC for all soils across the site would be expected to be at a similar level.

**TABLE 5-7****CATION EXCHANGE CAPACITY  
BIG CHIEF-GOLCONDA MINE SITE**

Sample	Waste Type	CEC meq/100g
BIG-CRI TP1B	Soil under Waste Rock	18.1
BIG-CRI TP2B	Soil under Waste Rock	17.1

Notes: CEC Cation exchange capacity  
meq/100g Milliequivalents per 100 grams of soil

**5.4.3 Agronomic Analysis**

Agronomic or agricultural analysis is used to evaluate the potential fertility and availability of nutrients to plants in the subsurface soils. Agronomic analysis includes pH, nitrate, available phosphorus, potassium, Shoemaker, McLean, and Pratt (SMP) pH, and SMP lime requirement. Agronomic analyses were completed for subsurface soils to evaluate the potential for in situ revegetation once the waste is removed and to identify the amount of fertilizer and other amendments that may be needed. The requirement for lime also is roughly estimated as part of the agronomic analysis. This lime requirement is calculated using the more simplified double-buffer SMP method, which may not take into account neutralization of all pyrite and pyritic-sulfur compounds in the soil.

The same two samples for partial agronomic analysis were TP-1B and TP-2B. Both samples were collected from the native soil horizons that have been buried below waste rock at the Big Chief mine for more than 60 years. The results are presented in Table 5-8 and are contained in Appendix D. The soils are highly acidic (pH 2.3 in sample TP-1B and pH 3.4 in sample TP-2B) and are low in the plant-required nutrients nitrogen, phosphorus, and potassium. The analysis shows that the site soils will require a fairly substantial amount of lime. The nutrient levels in these soils are low, and fertilizer would need to be provided during reclamation and potentially in follow-up applications. Adjusting the pH of the soil to more neutral levels (pH 5.5 to 6.5) should help reduce the potential for phytotoxic levels of metals to inhibit plant growth or sustained vegetation.

**TABLE 5-8**  
**AGRONOMIC ANALYSIS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Sample	Description	pH	Nitrate	Phosphorous	Potassium	SMP pH	SMP Lime Requirement
		S.U.	mg/kg	mg/kg	mg/kg	S.U.	tons/1,000
BIG-CRI TP1B	Subsurface Soil	2.3	<1	20	51	4.4	13.6
BIG-CRI TP2B	Subsurface Soil	3.4	5	144	264	5.0	13.6

Notes:

S.U.	Standard units
mg/kg	Milligrams per kilogram
tons/1,000	Tons lime per 1,000 tons of soil
<	Less than

#### 5.4.4 Potential Locations for Repository and Borrow Soil

A potential borrow site for reclamation cover soil is located directly south of the Big Chief-Golconda Mine Site. A potential waste repository was not located in the general area of the historical disturbance of the mine site, however. Areas with soils that do not contain metals at concentrations greater than recreational or residential cleanup guidelines are found near the mine. A fairly large, nearly level area is located immediately south of the mine site with well-developed soils. In general, the textures of the soils in the area are sandy and developed in situ from physical and chemical weathering of the granitic parent material (Boulder batholith). Some disturbed areas on site have begun to naturally revegetate with coniferous trees and grasses. This revegetation indicates that other disturbed areas can be reclaimed if cover soil is applied and a proper seed mixture is planted.

The soil materials identified for reclamation cover soil would require some amending with organic matter (compost, manure, or green manure) and adding inorganic fertilizer and lime. In particular, the buried soil horizons contain significant amounts of partially decomposed granitic rock, are inherently infertile, and have a low water-holding capacity. The buried surface soils may contain a small amount of residual organic matter, but the addition of compost or manure will help improve the nutrient cycling and increase the water-holding capacity.

#### 5.5 HUMAN HEALTH RISK ASSESSMENT

A screening-level human health risk assessment was conducted for the Big Chief-Golconda Mine Site as part of the RI in spring 2005. The risk assessment was conducted using current guidance set forth in (1)

“Risk-Based Cleanup Guidelines for Abandoned Site Sites” (Tetra Tech 1996); (2) standardized risk assessment spreadsheets developed by MWCB; and (3) guidance established by EPA (1989a). The risk assessment has been updated in this RI to reflect refined land use areas and to include additional data gathered at the site. Risk assessment data and calculation spreadsheets are in Appendix E.

The assessment involved five steps: (1) hazard identification; (2) exposure assessment; (3) toxicity assessment; (4) risk characterization; and (5) calculation of risk-based cleanup goals. The following sections discuss these five steps in greater detail.

### **5.5.1 Hazard Identification**

Hazard identification is conducted to identify the chemicals of concern (COC) for the site. Each COC must meet four criteria established by EPA (1989a): (1) the constituent is present at the site; (2) the measured concentrations of the constituent are significantly above background concentrations; (3) 20 percent of the measured concentrations of the constituent must be above the method detection limit; and (4) the analytical results for each constituent must meet the quality assurance/quality control (QA/QC) criteria established for the data set.

Twenty-seven solid-matrix samples and three surface water samples were collected during the RI for the Big Chief-Golconda Mine Site. All samples were analyzed at an off-site laboratory. The laboratory samples included surface soil and waste rock; four test pit samples, three background soil samples, and three sediment samples. The analytes at the site that met the limits of detection and QA/QC requirements were arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, and zinc (see Appendix E). Arsenic, cadmium, copper, iron, lead, manganese, silver, and zinc were detected at concentrations above background levels.

Surface water samples were collected from Golconda Creek upstream, at the mid-mine area, and downstream of the Big Chief-Golconda Mine Site. The samples were analyzed for antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, and zinc at an off-site laboratory. Concentrations of barium, cadmium, copper, iron, lead, manganese, and zinc in the surface water sample from the disturbed area of the creek bed were slightly greater than in the surface water sample collected upstream of the site.

### 5.5.2 Exposure Assessment

The exposure assessment identifies the human receptors who may be exposed, the exposure routes through which the receptors may come into contact with hazardous constituents, and the assumptions and data used to quantify the exposure.

The main exposure scenario developed for the Big Chief-Golconda Mine Site is for on-site recreation. Risks to recreational receptors at the site are included in the rockhound/goldpanner exposure scenario that was evaluated in the “Risk-Based Cleanup Guidelines for Abandoned Site Sites” (Tetra Tech 1996). The all-terrain vehicle/motorcycle rider (ATV/MR) exposure scenario was not evaluated since no tailings are present at the Big Chief-Golconda Mine Site. The potential for recreational use of the Big Chief-Golconda Mine Site is high based on its location off the main road to Tizer Lakes and its proximity to the surrounding communities of Corbin, Jefferson City, Boulder, and Helena. The recreational use also is ranked high because a cabin is present on the site. The frequency the cabin is used is unknown, and high use may result in risks greater than were estimated by this risk assessment. The fisherman exposure scenario was not included since Golconda Creek is too small to be a recreational fishery.

The maximum concentration of metals detected in site waste samples were used as the exposure point concentrations for this screening-level risk assessment for the Big Chief-Golconda Mine Site. The samples used for the risk assessment are listed in Table 5-9, and the exposure point concentrations are listed in Table 5-10.

**TABLE 5-9**

**SAMPLES USED FOR EXPOSURE POINT CONCENTRATIONS  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Waste Source</b>	<b>Sample Numbers</b>
Big Chief-Golconda Site Waste Rock	BC-002, BC-005, BC-006
Big Chief-Golconda Site Surface Water	BC-SW-002

**TABLE 5-10**  
**EXPOSURE POINT CONCENTRATIONS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Waste Type	Arsenic	Barium	Cadmium	Copper	Iron	Lead	Manganese	Silver	Zinc
Waste Rock (mg/kg)	153	--	68	883	45,600	32,300	4,630	143	12,300

Notes:

mg/kg Milligrams per kilogram

µg/L Micrograms per liter

-- Not included

### 5.5.3 Toxicity Assessment

The toxicity assessment phase evaluates the potential for COCs to cause adverse carcinogenic or noncarcinogenic effects in exposed populations. The most hazardous COCs identified at the Big Chief-Golconda Mine Site are arsenic, lead, and manganese. The following sections summarize the potential adverse effects and dose-response relationships for only these three metals. The other metals listed in Table 5-10 do not pose a significant risk to potential human receptors and were, therefore, excluded.

#### Arsenic

Arsenic is the twentieth most abundant element in the earth's crust and is present in virtually all living organisms. Freshwater supplies in certain areas of the United States and Canada contain up to 1.4 mg/L. Seafood can contain significant concentrations of arsenic, ranging from 2 mg/kg for freshwater fish to 22 mg/kg for lobsters, most of which is organically (protein) bound. The average adult dietary intake of arsenic is between 0.025 and 0.033 milligrams per kilogram per day (mg/kg/d). This amount is nearly twice the level EPA considers to produce adverse health effects in humans (that is, the lowest observed adverse effects level [LOAEL] = 0.17 mg/L or 0.014 mg/kg/d). The largest source of human exposure to arsenic is arsenical pesticides, which account for 80 percent of the industrial consumption of arsenic worldwide. However, other principal uses of arsenic include manufacture of pharmaceuticals, glass, ceramic products, and metallurgy.

Arsenic (and arsenic compounds), especially organic arsenicals, are readily absorbed into the body after inhalation, ingestion, or dermal contact. When they are ingested, soluble arsenic compounds, including solutions, are almost completely absorbed through the gastrointestinal tract. Conversely, insoluble

arsenic compounds are poorly absorbed, if at all. An orally administered dose of arsenic is distributed rapidly to virtually all tissue compartments (probably bound to protein), with the highest concentrations subsequently detected in the muscle, followed by the liver, hair, nails, and kidney. Excretion by the kidney is almost complete within 6 days and accounts for more than 90 percent of the dose. In liver tissue, trivalent arsenic ( $\text{As}^{+3}$ ) is converted by microsomal enzyme systems and excreted in urine as multiple metabolites, including dimethylarsenic acid (50 percent), methyl arsenic acid (14 percent), pentavalent arsenic (8 percent), and trivalent arsenic (8 percent). Organo-arsenic compounds as are typically found in crabmeat and other types of seafood are excreted essentially unchanged.

These “detoxification” processes effectively increase the molecular weight and polarity of the metal complex, thereby enhancing the rate of excretion in aqueous urine (half-life  $[t_{1/2}] = 7$  hours). Like lead, mercury, and other heavy metals, arsenic is readily incorporated in fingernails, toenails, bone, and hair, providing an additional means of assessing historical exposure.

Symptoms of acute arsenic exposure include vomiting and diarrhea caused by severe gastrointestinal distress and general vascular collapse. The estimated lethal doses for humans are 60 milligrams of trivalent arsenic ( $\text{As}^{+3}$ ) and 250 milligrams of pentavalent arsenic ( $\text{As}^{+5}$ ). The most frequently noted and characteristic effects of chronic arsenic toxicity in humans include skin lesions, peripheral vascular disease, cardiovascular abnormalities, and peripheral neuropathy. However, the most significant toxic effect of chronic or prolonged low-level exposure to arsenic is carcinogenicity, including increases in the incidence of respiratory and skin cancers. For example, repeated epidemiological studies have found an increased incidence of skin and respiratory tract tumors in persons exposed to arsenic fumes and dusts. Some studies have also reported increased bladder cancers. One study of elderly males in villages with arsenic-tainted drinking water showed a dose- and time-dependent response curve, with rates of skin cancer as high as 26 percent in men exposed to water containing more than 0.6 mg/L of arsenic. However, results of ingestion studies with animals have been generally equivocal.

Most reports of chronic arsenic toxicity have been in occupational settings from workers exposed to fumes and dusts, causing local irritation of the mucous membranes of the eyes and nose. Exposure is best diagnosed by measuring concentrations in the hair or urine. For example, concentrations of arsenic in the hair for unexposed persons are typically less than 1 mg/kg (average 0.5 mg/kg), whereas concentrations in subjects of chronic poisoning are often between 1 and 5 mg/kg and can range as high as 47 mg/kg.

Given its systemic distribution, arsenic is readily transported across the placenta to fetal tissues, but teratogenicity (birth defects) and other reproductive effects have not been reported in laboratory animals at low to moderate parental dosages. However, chromosomal aberrations have been documented in humans exposed to industrial sources of arsenic, and select arsenic compounds have been found to be mutagenic in both *in vivo* and *in vitro* studies.

Arsenic is a Class A (that is, known) human carcinogen. Its oral slope factor is listed in EPA's Integrated Risk Information System (IRIS) substance file (last updated April 10, 1998), as 1.5 mg/kg/d. No dermal slope factor was available for arsenic when this report was written. However, a dermal slope factor of 20 times the oral slope factor has been derived and employed on the basis that 5 percent of an ingested dose is absorbed by the gastrointestinal tract (EPA 1989a). The oral reference dose (RfD) reported in IRIS (EPA 1998) for arsenic toxicity in humans is 0.0003 mg/kg/d based on a chronic exposure study that produced hyper-pigmentation, teratosis, and possible vascular complications. The confidence level reported for this oral RfD was "medium." Unfortunately, no direct RfD for arsenic is available for the inhalation or dermal exposure pathways. As above, a dermal RfD value equal to 5 percent of the oral RfD has been derived, assuming that approximately 5 percent of the ingested arsenic will be absorbed by the gastrointestinal tract (EPA 1989a). No RfD was calculated for the inhalation pathway since there is no standard relationship between oral and inhalation RfDs for inorganic compounds (EPA 1989a). An uncertainty factor of three is deemed adequate for the arsenic RfD to account for outlying groups or effects, including so-called "sensitive" individuals, potential reproductive impacts, and other toxicological data gaps.

## **Lead**

Lead and inorganic lead compounds are found in a variety of commercial products and industrial materials, including paints, plastics, storage batteries, bearing alloys, insecticides, and ceramics. In addition, lead is naturally occurring in soils of the western United States at an average concentration of 17 mg/kg (Shacklette and Boerngen 1984).

Humans are in a state of positive lead balance from the day of birth, such that a relatively slow accumulation occurs until a total body burden of approximately 50 to 350 milligrams of lead has amassed by age 60. Normal adults have been shown to absorb approximately 5 percent of an oral dosage of various lead compounds, although absorption depends entirely on the individual and the nature of the lead compound in question. Research has shown that men typically have higher concentrations of lead in

nearly all tissues than do women, and further, that the developing fetus and adolescent children are the two most sensitive subpopulations.

More than 90 percent of absorbed lead is deposited in bone, primarily dense bone, with only minor amounts excreted in hair, nails, or urine. However, the average absorption of lead in children may be significantly higher than in adults (that is, as high as 50 percent). Inhalation studies have shown that about half the lead deposited in the alveoli of the lung is absorbed directly into the blood stream, and that most of the dosage (90 to 95 percent) is subsequently deposited in skeletal bone, where the half-life is estimated to be 7 to 10 years. Although the predominant elimination pathway for lead (and most heavy metals) is urine, the rate of urinary excretion is notably slow.

Lead has been shown to adversely affect many enzyme systems, but the overall health effects from exposure to lead are typically related to elevated blood-lead concentrations that can result in a variety of toxicological effects, depending on the level of exposure. For example, the most noteworthy clinical indices of lead toxicity in humans are its effects on heme (blood) synthesis, resulting in erythrocyte anomalies, and imbalances of porphyrin, protoporphyrin, and aminolevulinic acid. Generally, a concentration of 40 micrograms per deciliter ( $\mu\text{g}/\text{dL}$ ) is considered the normal upper limit for blood lead, 99 percent of which is typically contained within erythrocytes.

The general symptoms of chronic lead poisoning include gastrointestinal disturbances, anemia, insomnia, weight loss, motor weakness, muscle paralysis, and nephropathy. For example, blood-lead concentrations greater than 40  $\mu\text{g}/\text{dL}$  have been associated with damage to the central nervous system and kidneys, as well as pernicious anemia. Concentrations on this order have also been associated with reproductive effects, miscarriage in pregnant woman, and sterility in males. Blood concentrations of 30  $\mu\text{g}/\text{dL}$  and higher have been associated with defects in vitamin D metabolism and with learning deficits in exposed children.

The effects of exposure to lead at blood concentrations of 20  $\mu\text{g}/\text{dL}$  and lower are more difficult to define. Some studies have reported increased blood pressure in males, starting at blood concentrations of about 10  $\mu\text{g}/\text{dL}$ . Low-level exposure to lead during early childhood can cause multiple effects, including impaired intellectual and neurobehavioral development. In fact, it appears that some of these effects, particularly changes in the levels of certain blood enzymes and impaired neurobehavioral development of children, may occur at blood-lead levels so low as to be essentially without a “threshold.” Similar low-level exposures to lead during pregnancy have been shown to cause reduced birth weight and preterm

births. This sensitivity to lead toxicity extends from the fetal stage until growth ceases after puberty. Studies of blood-lead concentrations in children of industrially exposed fathers revealed that the blood-lead concentration in as many as 42 percent of the children was greater than 30 µg/dL and exceeded 80 µg/dL in more than 10 percent of the children as a result of lead carried home on contaminated clothing.

On the basis of bioassay results in rats and mice, EPA has classified lead as a Class B2 (that is, probable) human carcinogen. Controlled dosage studies in humans have produced renal tumors after dietary and subcutaneous exposures to soluble lead salts. However, dosages that typically induce cancer in humans are higher than are associated with other health effects of exposure to lead, such as reproductive and developmental toxicity and increased blood pressure.

Unfortunately, no standard carcinogenic slope factors or RfDs are available for lead. Although the “uptake biokinetic” model is used to calculate the risk to children in a *residential* land-use scenario, the model cannot be used to calculate risks to adults or children in *recreational* exposure settings. Therefore, a cancer slope factor or RfD must first be obtained or calculated to estimate the recreational risks from lead to the adult and child. Using the uptake biokinetic model with standard residential assumptions, the maximum safe concentration of lead for noncancerous effects has been set at 400 mg/kg. Therefore, standard residential child exposure assumptions were combined with an exposure point concentration of 400 mg/kg to calculate oral and dermal RfDs. The RfD was then adjusted until the hazard quotient (HQ) was equal to 1.0. The dermal RfD was calculated to be 5 percent of the oral RfD, assuming that approximately 5 percent of ingested lead is absorbed by the gastrointestinal tract (EPA 1989a). No RfD was calculated for inhalation since there is no standard relationship between inhalation and oral RfDs for inorganic compounds (EPA 1989a). Using the above derivation methods, the RfDs were calculated at 0.0026 mg/kg/d oral and 0.00013 mg/kg/d dermal.

## **Manganese**

Manganese is an abundant element, typically present in U.S. soils at an average concentration of 525 mg/kg (Kabata-Pendias and Pendias 1989). It is widely used in the industrial manufacture of steel alloys, dry-cell batteries, electrical coils, ceramics, matches, glass, dyes, fertilizers, welding rods, oxidizing agents, and a variety of food additives, and is naturally present in many foods. The biochemical role of manganese is to serve as an activator of several enzymes, including hydrolases, kinases, decarboxylase, and transferases. Thus, as a required co-enzyme for a number of metabolic reactions, manganese is an

essential trace element and a necessary dietary nutrient for humans. The average adult dietary consumption of manganese is the range of 2 to 9 mg/day.

Occupational exposures to manganese usually occur by inhalation or ingestion of fumes and dusts produced in refining manganese ores or treatment of manganese alloys. Most inhaled manganese is mobilized up the trachea and then swallowed. Like lead, the efficiency of gastrointestinal absorption of manganese is low, usually less than 10 percent, but is variable and appears to correlate inversely with the amount of the element available for absorption. The absorbed manganese leaves the blood quickly and is stored primarily in organ tissues; the half-life ( $t_{1/2}$ ) for excretion of manganese from the body in normal subjects is about 40 days.

When chronic overexposure to manganese occurs, it is typically manifest by a syndrome of neurologic and psychiatric disorders including headaches, restlessness, irritability, personality change, hallucinations, and hearing impairment. Severe toxicity can result in muscle weakness, rigidity, and tremor. Acute occupational exposures to manganese via inhalation have been reported to produce *pneumonitis*; chronic occupational exposure via inhalation has been reported to produce *manganism*. The latter disease (involving the central nervous system after exposure to high concentrations), produces cirrhosis of the liver and encephalopathy, when behavioral and neurological changes similar to Parkinson's disease are manifest. Acute toxicity studies in experimental animals have revealed histopathological changes, pulmonary congestion, and edema of the lungs. Different compounds of manganese are reported to produce opposing effects in the blood, including damage to erythrocytes. In addition, studies of humans and experimental animals suggest that oral exposure to elevated levels of manganese affect the cardiovascular and central nervous systems and can result in decreased fertility.

Manganese is known to be sequestered primarily in the liver, followed by the kidney, intestine, and pancreas. Homeostatic mechanisms in the body maintain relatively constant tissue concentrations and are perhaps responsible for the lack of systemic toxicity after chronic oral exposure. However, absorption levels after inhalation and dermal exposures to manganese have not been well characterized. In fact, results of absorption studies conducted with manganese show significant disparities between exposed adults and newborns. (Blood absorption has been reported at 3 percent for orally dosed adults and at 70 percent for orally dosed newborns.)

Information available in EPA's IRIS database indicates that the oral RfD for manganese is 0.14 mg/kg/d. However, perhaps more than most metals, individual requirements for, as well as adverse reactions to,

manganese may be highly variable. Some individuals may, in fact, consume a diet that contributes more than 10 mg/day (more than four times the oral RfD) without cause for concern. This information, in conjunction with the essential nutrient of manganese, warranted a confidence level in the RfD of “medium” and an uncertainty factor of 1.

#### 5.5.4 Risk Characterization

Risk characterization is completed using the exposure assumptions and toxicity assessment data to calculate the carcinogenic and noncarcinogenic risk for adults for a recreational exposure scenario. The following sections describe the risk calculations and the associated uncertainty.

#### Risk Calculations

The carcinogenic and noncarcinogenic risks to potential human receptors from arsenic, cadmium, copper, iron, lead, manganese, silver, and zinc in soil were calculated for the Big Chief-Golconda Mine Site. Data from the Big Chief-Golconda Mine Site were evaluated using the rockhound/goldpanner recreational exposure scenario. Tables that summarize the risk calculations are located in Appendix E. Individual HQ values and relative percent contributions to total risk for arsenic, lead, and manganese in soil and surface water are summarized in Table 5-11. The other metals were not included because their total HQs were less than 0.1. Table 5-12 lists the total (soil and water) carcinogenic (E-06) and noncarcinogenic hazard index (HI) risk values for the recreational exposure scenario. The HI is the sum of the HQs for individual metals.

**TABLE 5-11**  
**RECREATIONAL SCENARIO**  
**CONTAMINANT-SPECIFIC HQ VALUES FOR SOIL AND WATER**  
**BIG CHIEF-GOLCONDA MINE SITE**

Site	Exposure Scenario	Hazard Quotient for Soil			
		Arsenic	Lead	Manganese	Total HI
Big Chief-Golconda Site	Rockhound/Goldpanner	0.5 (3)	14.7 (92)	0.6 (4)	15.9 <sup>a</sup>

Notes:

- <sup>a</sup> The total HQ is greater than the sum of arsenic, lead, and manganese due to the contribution of all the other metals.
- (#) Percent contribution to total HQ.
- HQ Hazard Quotient (relative toxicity value for a single metal in a single medium)
- HI Hazard Index

**TABLE 5-12**

**RISKS CALCULATED FOR RECREATIONAL SCENARIO  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Site</b>	<b>Exposure Scenario</b>	<b>Risk</b>	<b>Total</b>
Big Chief-Golconda Site	Rockhound/goldpanner	Carcinogenic (E-06)	1.1 E-04
		Noncarcinogenic (HI)	15.9 <sup>a</sup>

Notes:

- <sup>a</sup> Includes risk from exposure to soil.
- E-06 Per million subjects exposed.
- HI Hazard Index (the sum of Hazard Quotients HQ for all metals).

EPA uses a carcinogenic risk of 1.0E-06 and an HI of 1.0 as the threshold levels for assessing the need for contaminant cleanup. As can be seen in Table 5-12, the rockhound/goldpanner recreational exposure scenario resulted in carcinogenic risk and HI values above the threshold levels (that is, risk = 1.1 E-04 and HI = 15.9) in risk calculations for the Big Chief-Golconda Mine Site. As can be seen in Table 5-11, lead accounted for the most risk (92 percent) followed by manganese (4 percent) and arsenic (3 percent) for the rockhound/goldpanner exposure scenario. Arsenic accounted for all of the carcinogenic risk at the site.

**Uncertainties in the Risk Calculations**

Uncertainty in the risk values calculated can be introduced by a number of factors, including: (1) exclusion of exposure pathways from the risk calculation, (2) inaccurate land use and exposure values, (3) the accuracy of the toxicity values, (4) the accuracy of the exposure point concentrations, and (5) exclusion of potentially hazardous constituents. Table 5-13 lists the relative effect of these sources of error on the calculated risk values. Each uncertainty factor is discussed below.

- (1) **Exclusion of exposure pathways from the risk calculation.** The exclusion of exposure pathways from risk calculations as a result of data gaps or the lack of applicable toxicity values will underestimate potential risk. The total site risk is the sum of the individual risks posed by each pathway (for example, soil, waste rock, or surface water).
- (2) **Inaccurate land use and exposure values.** The exclusion of potentially hazardous constituents caused by unreliable field data will underestimate risk. The total site risk is the sum of all risks from potentially hazardous constituents present in all media. The exclusion of contaminants from the risk calculations as a result of inferior data quality reduces the calculated risk values. Potentially hazardous constituents detected at the site but not subjected to risk calculations include antimony and cadmium. The amount of underestimation for risk posed by these metals is unknown, but is probably less than one order of magnitude.

- (3) **Accuracy of the toxicity values.** Conservative estimations for land use and exposure assumptions will overestimate site risks. The land use assumptions were based on a visual inspection of the site. All areas with the potential for recreational use by humans were included in the recreational risk area. The exposure assumptions used in the risk assessment are standard values thought to be conservative. The amount of overestimation of risk caused by these assumptions is unknown, but is not likely to exceed one order of magnitude.
- (4) **Accuracy of the exposure point concentrations.** The magnitude of toxicity values strongly affects the risk value calculated. However, the reference toxicity values used in the current risk assessment were conservative, likely overestimating risk. The methodology used to develop reference toxicity values assures that the value will overestimate rather than underestimate the potential risk. The toxicity values calculated during this risk assessment are also likely to be conservative since they are derived from conservative starting points using conservative assumptions. The amount of overestimation from the use of toxicity values is unknown, but should not exceed one order of magnitude.
- (5) **Exclusion of potentially hazardous constituents.** The accuracy of calculated exposure point concentrations is unknown. However, the calculated exposure point concentrations used in this risk assessment are likely underestimate site risk. A mean or average concentration of the metal in soil was used in the risk assessment, although concentrations of metals are above average in many areas. Thus, the risk to a receptor exposed to areas with higher concentrations of metals would be underestimated. Depending on the metal in question, the risk posed may be greater or less than was estimated by the risk assessment.

**TABLE 5-13**

**SUMMARY OF UNCERTAINTIES FOR RISK ASSESSMENT  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Source of Uncertainty</b>	<b>Probable Effect</b>
Exclusion of exposure pathways from the risk calculation	Underestimate <1 OM
Exclusion of potentially hazardous constituents	Underestimate <1 OM
Inaccurate land use and exposure values	Overestimate up to 1 OM
Accuracy of the toxicity values	Overestimate up to 1 OM
Accuracy of the exposure point concentrations	Over- or under-estimate << 1 OM

Notes:

OM     Order of magnitude

### **5.5.5 Risk-Based Cleanup Goals**

Risk-based cleanup goals are calculated to allow for the design and implementation of reclamation. Table 5-12 shows the carcinogenic and noncarcinogenic risks for the recreational exposure scenario at the Big

Chief-Golconda Site. Table 5-14 lists the cleanup goals for soil (by individual analyte) for carcinogenic and noncarcinogenic risks posed in a recreational land use scenario.

**TABLE 5-14**  
**RECREATIONAL RISK-BASED CLEANUP GOALS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Moderate Recreational Use Value (5)	50-Day Rockhound/Goldpanner Scenario	
Metal	Soil (mg/kg)	Water (µg/L)
Arsenic	323 <sup>a</sup>	153 <sup>b</sup>
Lead	2,200	220
Manganese	7,330	2,560

Notes:

<sup>a</sup> The noncarcinogenic cleanup guideline for soil is 323 mg/kg. The carcinogenic cleanup guideline for soil is 139 mg/kg.

<sup>b</sup> The noncarcinogenic cleanup guideline for water is 153 µg/L. The carcinogenic cleanup guideline for water is 66.2 µg/L.

mg/kg Milligrams per kilogram

µg/L Micrograms per liter

### 5.5.6 Risk Characterization Summary

The risk values summarized for the Big Chief-Golconda Mine Site in Tables 5-11 and 5-12 indicate that the site poses a potential risk to recreational users. The HIs calculated can be used to decide whether human receptors are potentially exposed to harmful doses of site-related contaminants via the high-use recreational scenario evaluated.

Lead posed most of the noncarcinogenic risk, followed by manganese and arsenic, for the 50-day rockhound/goldpanner exposure scenario. The carcinogenic risks calculated for the Big Chief-Golconda Mine Site exceed the threshold level of 1.0E-04 for assessing the need for contaminant cleanup. These HQs, carcinogenic risks, and various qualitative observations demonstrate that contaminants at the site constitute probable adverse human health effects for the recreational land use scenario. Consequently, cleanup measures for the site are warranted.

## 5.6 ECOLOGICAL RISK ASSESSMENT

A baseline ecological risk assessment was conducted at the Big Chief-Golconda Mine Site for terrestrial plant communities, aquatic life communities, and terrestrial wildlife exposure scenarios using contaminant concentrations measured during the RI conducted in the spring of 2005. The assessment involved initial identification of COCs followed by development of an exposure assessment, an ecological effects assessment, and a risk characterization.

The ecological risk assessment was carried out for the Big Chief-Golconda Mine Site using several key federal guidance documents, including: (1) EPA's "Risk Assessment Guidance for Superfund: Volume II — Environmental Evaluation Manual" (EPA 1989b); (2) EPA's "Framework for Ecological Risk Assessment" (EPA 1992); (3) EPA's "Wildlife Exposure Factors Handbook" (EPA 1993); and (4) EPA's "Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment" (EPA 1994). The mining waste at the site may pose a potential risk not only to humans but also to plants and animals that come into contact with them. Ecological risk assessments exclude the potential for effects on people and domesticated species, such as livestock. However, the health of people and domesticated species is inextricably linked to the quality of the environment shared with other species. The ecological evaluation that follows is intended as a qualitative screening-level ecological risk assessment (SLERA) because of the limited and indirect nature of the data available for the site.

The SLERA estimates the effects of taking no action at the site and involves four steps: (1) identification of contaminants, ecological receptors, and ecological effects of concern; (2) exposure assessment; (3) ecological effects assessment; and (4) risk characterization. These four tasks are accomplished by evaluating available data and selecting contaminants, species, and exposure routes of concern, estimating exposure point concentrations and intakes, assessing the ecological toxicity of the COCs, and characterizing overall risk by integrating the results of the toxicity and exposure assessments.

Environmental contaminants at the Big Chief-Golconda Mine Site that could affect ecological receptors include high concentrations of metals in waste rock and adit discharge. The vegetative communities on site have been affected by metals toxicity, as evidenced by the lack of vegetation on the waste rock. The waste materials and vegetation in the area are easily accessible to wildlife and could result in significant ecological effects. The objective of this SLERA is to estimate current and future effects of implementing the no-action alternative at the Big Chief-Golconda Mine Site.

### **5.6.1 Contaminants and Receptors of Concern**

This SLERA evaluated the potential for contact between ecological receptors and the COCs. The qualitative results of the SLERA may be used to identify the need for and the extent of the reclamation efforts. In addition, the SLERA is useful in identifying the exposure pathways and biological characterization of the site that are important for the human health risk assessment.

#### **Contaminants of Concern**

To be considered a COC, the metal must be detected at the site, be represented by data that meet the QA/QC criteria, and be present at concentrations above background. The analytes that meet these requirements for soil are arsenic, cadmium, copper, iron, lead, silver, and zinc. Cadmium, copper, iron, lead, and zinc were detected in samples collected from Golconda Creek adjacent to the site at concentrations above the concentrations measured in the upstream samples; they are used for aquatic life in water and ingestion of water by deer.

Data tables in Section 5.3 summarize the detectable concentrations for metals in samples of soils, waste rock, sediment, and surface water. These COCs are characteristic of hard rock mining wastes and should reliably represent contamination associated with mining at the Big Chief-Golconda Mine Site. However, no ecological toxicity data are available for several of these contaminants to evaluate potential effects. The following toxicological data pertain to arsenic, cadmium, copper, lead, and zinc, the primary COCs identified in the SLERA.

#### **Arsenic**

Although arsenic is an essential nutrient and occurs naturally in the environment and in all organisms, it is also a teratogen and a “known” carcinogen that can traverse placental barriers and produce fetal death and malformations in many species of mammals (Eisler 1988a). Its bioavailability and toxicity are modified by many biotic and abiotic factors that include the physical and chemical forms of arsenic, the route of exposure, the dosage, and the species of affected organism. In general, inorganic arsenic compounds are more toxic than are organic arsenic compounds (that is, arsenicals), and trivalent species are more toxic than pentavalent species. Arsenic has been demonstrated to bioconcentrate, but not biomagnify, in certain organisms (Eisler 1988a).

Terrestrial plants accumulate arsenic by root uptake from the soil and by adsorption of airborne arsenic deposited on the leaves. Studies have shown that certain plant species can accumulate substantial levels (Agency for Toxic Substances and Disease Registry [ATSDR] 1993a). The effects of arsenic on mammals vary by species, exposure route or pathway, and the physical and chemical form of the arsenic. Many mammals can rapidly excrete ingested inorganic arsenic (Eisler 1988a). However, arsenic is distributed to most tissue compartments, including placental and fetal tissues.

### **Cadmium**

Cadmium is considered a nonessential element for plants and animals. The solubility of cadmium has been determined to be pH-dependent. Cadmium can be readily solubilized during natural soil weathering processes. Cadmium is most mobile in acidic soil and may be easily taken up by plants under these conditions. Elevated concentrations of cadmium have been shown to retard plant growth by causing root damage, chlorosis in the leaves, and red-brown coloration of leaf margins or veins (Kabata-Pendias and Pendias 1989). Studies of plant growth have found that uptake of cadmium by roots and foliar systems may be reduced by the presence of plant-available zinc.

### **Copper**

Copper forms several common minerals in soils, the primary are simple and complex sulfides. These sulfide minerals are easily solubilized during the soil weathering processes, when copper ions are released and commonly accumulate in the upper soil horizons. Copper is one of the more mobile “heavy metals,” especially in acidic soil environments. Once it has been absorbed into plant tissues, copper appears to be far less mobile. Copper is considered the most toxic common heavy metal to aquatic organisms. This toxicity is inversely related to the hardness of the water, however: the harder the water, the less toxic copper is to aquatic organisms. Studies indicate that copper is also highly toxic to plants and will cause chlorosis and root malformation (Kabata-Pendias and Pendias 1989). Some plants, such as Redtop (*Agrostis tenuis*) and Tufted hairgrass (*Deschampsia caespitosa*) have been shown to evolve tolerance to elevated levels of copper in soils. Continued ingestion of copper by animals can lead to accumulation in tissues, particularly in the liver (Underwood 1971).

## **Lead**

Lead has been known to be a common pollutant and a potent environmental poison that is capable of altering normal blood formation and nervous system functions of the human body (Eisler 1988b). When absorbed in excessive amounts, lead can have carcinogenic properties, impair reproduction and liver and thyroid function, and interfere with resistance to infectious disease (EPA 1984). Lead is toxic in most of its chemical forms and can be incorporated into the body via inhalation, ingestion, dermal absorption, and placental transfer. Lead is also a known mutagen and teratogen.

The fate of lead in soil and soil solutions is affected by a variety of factors, including precipitation of sparingly soluble forms of lead; formation of relatively stable organic-metal complexes or chelates with soil organic matter; the soil's pH, CEC, and organic matter content; and the amount of lead in the soil (ATSDR 1993b). Most forms of lead are retained rather strongly in soil; thus, very little tends to leach from the soil. Lead can be transported via erosion of lead-containing soil particulates, which can then be deposited in surface waters (ATSDR 1993b). Lead is not an essential element for plants, and excessive amounts have been shown to inhibit growth (Eisler 1988b). The effects of lead on mammals can include growth retardation, delays in maturation, and reduced body weight.

## **Zinc**

Zinc is found in fairly uniform concentrations in rocks and soils and may range from about 10 ppm to 120 ppm (Kabata-Pendias and Pendias 1989). Zinc is considered an essential nutrient for both plants and animals. Soluble forms of zinc are easily taken up by plants, particularly by the root systems. Zinc will commonly accumulate in the upper soil horizons during weathering processes. Zinc is not considered highly phytotoxic, but its toxicity is more prevalent in acidic soils. Several plant species and genotypes are known to have evolved a degree of tolerance to elevated levels of zinc in soils, and some species may accumulate large amounts of the metal without showing overt symptoms of toxicity. Chlorosis (seen mainly in newly developed leaves) and depressed plant growth are the common symptoms of zinc toxicity (Kabata-Pendias and Pendias 1989).

## **Ecological Receptors of Concern**

A variety of plants, birds, amphibians, and mammals are part of the general food web for the Big Chief-Golconda Mine Site, and many more species could be included in a more extensive ecological

assessment. This SLERA has identified three groups of ecological receptors that are potentially affected by chemical contamination at the Big Chief-Golconda Mine Site. The first group of potential receptors is the terrestrial plant communities, which are noticeably absent on some of the areas of waste rock. Plant communities are of concern because they represent the first trophic level in the food chain and are consumed by many higher trophic level animals.

The second group of potential ecological receptors is the terrestrial wildlife that may use the area as part of the home range, including elk and mule deer. TtEMI personnel observed evidence of use by elk and mule deer during the RI field investigation. Grazing by wildlife species at this site is of concern because of the potential that they will consume contaminated vegetation, soil, and evaporative salts. The only terrestrial wildlife receptors evaluated in a quantitative manner in this ecological risk assessment are deer. Deer are assumed to represent the highest level of exposure to site contaminants, and the effects to deer can apply to other potential receptors.

The third group of potential receptors is the aquatic life communities. Golconda Creek is moderate habitat for aquatic life. The stream is perennial; however, the flow rate is low.

### **Ecological Effects of Concern**

One ecological effect observed is that some areas (waste rock) on site are essentially devoid of vegetation. The lack of vegetation in these areas may be partially caused by toxic and inhibitory levels of metals in the plant root zone along with other detrimental physical and chemical (infertility) properties of the soil. A second ecological effect of concern is the potential for deer and other wildlife to ingest contaminated vegetation, water, and evaporative salts that may form in the soils.

#### **5.6.2 Exposure Assessment**

The solid-matrix samples listed in Table 5-15 (BC-002, BC-005, and BC-006) were used for the exposure point concentrations for ingestion by deer and for phytotoxicity. Exposure point concentrations used for this SLERA (see Table 5-16) were from soil samples with the most “uniformly high” concentrations of metals detected at the Big Chief-Golconda Mine Site. Aquatic life was evaluated using data for water sample BC-SW-002 and sediment sample BC-SD-002. Samples BC-SW-002 and BC-SD-002 were collected from Golconda Creek adjacent to the site.

The three exposure scenarios discussed below were used to assess ecological risk. However, the only scenario that involved the calculation of a dosage was one where deer ingest contaminated soil, water, or salt. Contaminant criteria and toxicological indices used to assess both contamination and risk for the exposure scenarios were compiled from the following primary documents:

- Terrestrial plant communities: Gough and others 1979; Shacklette and Boerngen 1984; Kabata-Pendias and Pendias 1989; CH2M Hill 1987
- Terrestrial wildlife: Eisler 1988a and b; ATSDR 1993a and b; EPA 1993; Beyer and others 1994
- Aquatic life: Eisler 1988a and b; Long and Morgan 1991; Tetra Tech 1996

### **Plant — Phytotoxicity Scenario**

This scenario involves the limited ability of various plant species to grow in soils or wastes with high concentrations of arsenic, cadmium, copper, iron, lead, silver, and zinc. Plant sensitivity to certain arsenic compounds is so great that these compounds were used as herbicides for many years. Phytotoxic criteria reported in the literature for total arsenic in soils ranged from 15 to 50 mg/kg; the 50 mg/kg hazard level was considered appropriate for the Helena Valley, Montana (CH2M Hill 1987). Cadmium is toxic to plants at concentrations greater than 8 mg/kg. Lead is also considered toxic to plants. Numerous phytotoxic concentrations are reported in the literature and generally range from 100 mg/kg (Kabata-Pendias and Pendias 1989) to 1,000 mg/kg (John and Van Laerhoven 1972, CH2M Hill 1987). Zinc is only moderately toxic to plants at concentrations more than 300 mg/kg (Kabata-Pendias and Pendias 1989). A tolerable concentration of 200 mg/kg zinc in soil has been previously cited for the Helena Valley (CH2M Hill 1987).

### **Ingestion by Deer Scenario**

Estimates of total intake dosage for deer are based on reported literature values and the following assumptions: (1) the currently unvegetated areas do not provide habitat for deer; (2) native vegetation is growing across most areas of the site and would be available to deer that graze in the area; and (3) the average weight of an individual adult deer is 68.04 kilograms (150 pounds).

### ***Intake of Contaminated Soil and Salt***

The daily uptake of salt for deer is based on data in “Elk of North America” (USDA 1995), which reported a range of 1 to 11 pounds (average 6 pounds) in 1 month for a herd of 50 to 75 elk (average 63 head). Assuming deer require 50 percent of the volume of salt for elk, a median exposure (non-conservative) approach would equate to an average salt use of 3 pounds per month. Using the average herd size of 63, the average individual salt uptake would equal 0.0016 pounds per day (lbs/day), or 0.00072 kilograms per day (kg/day). Beyer and others (1994) estimated that ingestion of soil accounts for less than 2 percent of the average Wyoming mule deer’s diet of 1.39 kg/day of vegetation, which would equal 0.0278 kg/day of soil. The arithmetic average concentrations of metals for the surface soils across the site were used for both the salt and soil levels since these values were the highest calculated.

### ***Intake of Metals in Vegetation***

Beyer and others (1994) estimated that an average mule deer ingests 1.39 kg of vegetation per day in summer. No vegetation samples were collected for analysis during the RI. The concentrations of arsenic (50 ppm), lead (25 ppm), and zinc (50 ppm) used in this calculation were the tolerable levels in vegetation (the lowest phytotoxic tissue levels) from the East Helena assessment (CH2M Hill 1987). The concentration for copper (15 ppm) was estimated based on data obtained from Kabata-Pendias and Pendias (1989). The metals-contaminated areas at the Big Chief-Golconda Mine Site cover about an acre. This area would represent 0.3 percent of an estimated average mule deer’s home range of 90 to 600 acres (average of 345 acres; Beyer and others 1994).

### **Aquatic Life Scenario**

This scenario involves the limited ability of aquatic organisms to survive in waters that have been contaminated with mining wastes, and specifically metals. Toxicity of metals to aquatic organisms depends on the concentration in the surface water and sediment, as well as other conditions such as water hardness, temperature, and pH.

### **Cadmium**

Cadmium can be lethal to fish and insects and has been found to impair growth at low concentrations. Cadmium toxicity has been shown to be inversely related to water hardness. Cadmium is known to bioconcentrate in the food chain.

### **Copper**

Copper has been shown to be the most common heavy metal that causes toxicity to aquatic organisms. Copper toxicity has been shown to be inversely related to water hardness.

### **Lead**

Concentrations of lead have been shown to affect early life stages of aquatic macrophytes, especially in soft water at warmer temperatures. Nonlethal effects of lead on fish include excess mucus formation interfering with respiration, spinal curvature, damage to organs, and reduced swimming ability. Lead is only minimally biomagnified in the food chain.

### **Zinc**

Although zinc is an essential nutrient to aquatic biota, toxic effects at high concentrations can include mortality, reduced growth, and inhibited reproduction. Embryos and juveniles have been found to be most sensitive to the effects of zinc. In addition, the effects of zinc on aquatic organisms are increased by the presence of other metals such as cadmium and mercury.

#### **5.6.3 Ecological Effects Assessment**

The effects of the COCs at this site are available from several literature sources and are not repeated here. No site-specific toxicity tests were performed to support this SLERA. Instead, only existing and proposed toxicity-based criteria and standards were used for this SLERA. The following sections detail the specific standards and data that were used for comparison to the analytical results of the RI field sampling investigation.

### **Plant — Phytotoxicity Scenario**

A summary of the phytotoxicity for selected metals of concern (Kabata-Pendias and Pendias 1989) is provided in Table 5-15. These concentrations were used for comparison to concentrations of metals in waste rock. The availability of contaminants to plants and the potential for plant toxicity depend on many factors, including soil pH, soil texture, nutrients, and plant species.

**TABLE 5-15**  
**SUMMARY OF TOLERABLE AND PHYTOTOXIC SOIL**  
**CONCENTRATIONS (mg/kg dry weight)**  
**BIG CHIEF-GOLCONDA MINE SITE**

<b>Element</b>	<b>Tolerable Soil Level (CH2M Hill 1987)</b>	<b>Phytotoxic Soil Concentrations (Kabata-Pendias and Pendias 1989)</b>
Arsenic	50	15 to 50
Cadmium	Not determined	4 to 8
Copper	Not determined	60 to 125
Lead	25	100 to 400
Zinc	50	70 to 400

Notes:  
mg/kg            Milligrams per kilogram

### **Ingestion by Deer Scenario**

Adverse effects data for test animals were obtained from the ATSDR toxicological profiles (1993a; 1993b), and from other literature sources (Eisler 1988a; 1988b). The data consist of dose (intake) levels that either cause no observed adverse effects levels (NOAEL) or the lowest dose observed to cause an adverse effect (LOAEL) in laboratory animals. The use of effects data for other species introduces an uncertainty factor to the assessment; however, effects data for all metals are not available for the species of concern (deer). The lethal arsenic dose of 34 mg/kg/d for deer (Eisler 1988a) is also included. Data for laboratory animals (primarily rats) have been adjusted only for increased body weight. These data are listed in Table 5-16.

**TABLE 5-16**

**MAMMALIAN TOXICOLOGICAL DATA FOR INORGANIC METALS  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Dose</b>	<b>Arsenic</b>	<b>Cadmium</b>	<b>Copper</b>	<b>Lead</b>	<b>Zinc</b>
NOAEL <sup>a</sup> - Rat	3.2	0.271	22.5	0.05	55
LOAEL <sup>b</sup> - Rat	6.4	2.706	90	5	571
References	ATSDR 1993a	Sample et. Al. 1996	NAS 1980	ATSDR 1993b; Eisler 1988b	Maita and others 1981
Lethal – Deer	34	NA	NA	NA	NA
Reference:	Eisler 1988a	NA	NA	NA	NA

Notes:

- <sup>a</sup> No Observed Adverse Effect Level (NOAEL)  
<sup>b</sup> Lowest Observed Adverse Effect Level (LOAEL)  
 NA Not Available  
 NAS National Academy of Sciences  
 ATSDR Agency for Toxic Substances and Disease Registry  
 All units are milligrams per kilogram per day (mg/kg/d)

### **Aquatic Life Scenario**

Montana water quality standards were compared with analytical data from surface water in Golconda Creek. Analytical results were adjusted for conditions such as water hardness, temperature, and pH, which can affect the toxicity of metals to aquatic organisms in the surface water bodies. Montana water quality standards for aquatic life are presented in Table 5-17.

#### **5.6.4 Risk Characterization and Summary**

This section combines the ecological exposure estimates and concentrations presented in Section 5.6.2 and the ecological effects data presented in Section 5.6.3 to provide a screening-level estimate of potential adverse ecological impacts for the two scenarios evaluated. This screening-level estimate was achieved by generating “ecological impact quotients” (EQ) that are analogous to the HQs calculated for human exposures to noncarcinogens. EQs were calculated for each contaminant of concern by exposure scenario or receptor type and are summarized in Table 5-18. Contaminant-specific EQs were generated by dividing the specific intake estimate or concentration by available ecological effect values or concentrations. Tables that summarize the risk calculations are found in Appendix E. As with HIs, adverse ecological impacts are not expected at the Big Chief-Golconda Mine Site if EQs are less than 1.

**TABLE 5-17****MONTANA SURFACE WATER QUALITY  
AQUATIC LIFE STANDARDS (µg/L)**

<b>Metal</b>	<b>Acute Toxicity</b>	<b>Chronic Toxicity</b>
Antimony (Sb)	88 <sup>a</sup>	30 <sup>a</sup>
Arsenic (As) - inorganic	360	190
Barium (Ba)	1,000 <sup>b</sup>	--
Cadmium (Cd)	1.1 <sup>c</sup>	0.2 <sup>c</sup>
Chromium (as Cr <sup>+3</sup> )	1,022 <sup>c</sup>	49 <sup>c</sup>
Cobalt (Co)	--	--
Copper (Cu)	9.2 <sup>c</sup>	6.5 <sup>c</sup>
Cyanide (CN) - total	22	5.2
Iron (Fe)	--	1,000
Lead (Pb)	33.8 <sup>c</sup>	1.3 <sup>c</sup>
Manganese	50 <sup>b</sup>	--
Mercury (Hg) - total	1.7	0.91
Nickel (Ni)	789 <sup>c</sup>	88 <sup>c</sup>
Zinc (Zn)	65 <sup>c</sup>	59 <sup>c</sup>

**Notes:**

<sup>a</sup> U.S. EPA (2002) criteria used since the contaminant is not included in Montana standards.

<sup>b</sup> Ambient water quality standards for protection of human health for consumption of fish.

<sup>c</sup> At an assumed hardness of 50 mg/L.

-- Standard has not been adapted or information is currently unavailable.

Reference: Montana Department of Environmental Quality (2001). Montana Numeric Water Quality Standards (Circular WQB-7), Water Quality Division, Helena, Montana.

**Plant - Phytotoxicity Scenario**

Maximum concentrations of metals collected from the source area at the Big Chief-Golconda Mine Site were compared with high values of the range of plant phytotoxicity derived from the literature. One limitation of this comparison is that the phytotoxicity ranges are not species-specific; instead, they represent toxicity to species that may or may not be present at the Big Chief-Golconda Mine Site. Additionally, other physical characteristics of the waste materials may create microenvironments that limit growth and survival of terrestrial plants directly or in combination with substrate toxicity.

Concentrations of metals are likely to be elevated in waste materials at the site; in addition, organic content is low, nutrients are limited, and the materials may harden enough to resist root penetration. The results of the EQ calculations for this scenario are presented in Table 5-18.

**TABLE 5-18**

**ECOLOGICAL IMPACT QUOTIENTS  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Receptor</b>	<b>Arsenic</b>	<b>Cadmium</b>	<b>Copper</b>	<b>Lead</b>	<b>Zinc</b>	<b>Total EQ By Receptor</b>
Plant Phytotoxicity	3.1 (2.4)	8.5 (6.5)	7.1 (5.5)	80.8 (62.1)	30.8 (23.7)	130
Deer Ingestion	0.0004 (0.0)	0.08 (0.08)	0.0002 (0.0)	103 (99.7)	0.0004 (0.0)	103
Aquatic Life - Surface Water	NA	0.38 (16)	0.33 (14)	0.56 (24)	1.1 (47)	2.3
Aquatic Life – Sediment	NA	NA	NA	7.2 (100)	NA	7.2
TOTAL EQ BY COC	3.1 (1.3)	9.0 (3.7)	7.4 (3.0)	192 (79)	31.8 (13)	243

Notes:

( )            Percent contribution to total receptor EQ.  
EQ            Ecological Impact Quotient (relative toxicity value for a single metal in a single medium)  
NA            Not Applicable  
COC           Contaminant of Concern

The EQs calculated for plant phytotoxicity at the Big Chief-Golconda Mine Site were greater than 1.0 for arsenic, cadmium, copper, lead, and zinc. The non-conservative assumption of using the high end of the phytotoxicity range to derive the EQs may underestimate the potential phytotoxic effect to some plant communities. However, several other factors in addition to phytotoxicity combine to adversely affect plant establishment and successful reestablishment on waste materials. In addition, the maximum concentrations of metals in soil were used as the plant dosage value in the EQ calculation, so that an overly conservative EQ is likely.

### **Ingestion by Deer Scenario**

Estimated deer ingestion doses were compared with the higher of the literature-derived toxicological effect levels (that is, the LOAEL). The contaminant-specific EQs were generated by dividing the total intake estimates by the toxicological effect values. Again, the comparison is limited because of the use of effects data for other species (rat) that were adjusted only for increased body weight. The species used in the toxicological studies may have been more or less susceptible to the contaminant in question than are deer. The results of the EQ calculations for this scenario are also presented in Table 5-18.

The EQs calculated for the deer ingestion scenario exceeded 1.0 for lead only. This EQ indicates a potential risk to deer and other wildlife as a result of lead in surface soils.

The assumptions used to derive the uptake dose and the comparison to rat toxicity may incorrectly estimate the actual average contaminant intake for deer. This potential for an adverse effect can be extended to other wildlife that may also use the area for a source of food and salt.

### **Aquatic Life Scenario**

Maximum concentrations in surface water and sediment collected from the Big Chief-Golconda Mine Site were compared with acute aquatic water quality criteria and other toxicity standards derived from Long and Morgan (1991). Acute aquatic water quality criteria were applied to this scenario because of the presence of drainage and the current lack of aquatic life. The presence of metals in surface water and sediments does not significantly affect the aquatic life in Golconda Creek. The results of the EQ calculations for this scenario are presented in Table 5-18.

Information presented in Table 5-18 indicates that the potential exists for adverse ecological impacts from surface water and sediment to aquatic life communities at the Big Chief-Golconda Mine Site. The acute EQs calculated for surface water were greater than 1.0 only for zinc. The EQs for sediment were greater than 1.0 for lead.

### **Risk Characterization Summary**

The EQs calculated can be used to evaluate whether ecological receptors are potentially exposed to harmful dosages of site-related contaminants via the three ecological scenarios evaluated. The EQs calculated for the Big Chief-Golconda Mine Site indicate that lead is the greatest overall risk driver for the site, with an EQ of 192. The risk posed by lead is divided among ingestion by deer (EQ = 103), aquatic life-sediment (EQ = 7.2), and plant toxicity (EQ = 80.8). Lead (EQ = 1103) poses virtually all (99.7 percent) of the risk to deer. Zinc (EQ = 31.8) poses a significant risk to plant toxicity (EQ = 30.8) and a lesser risk for aquatic organisms through surface water (EQ = 1.1). Cadmium (EQ = 9.0) poses a significant risk to plant toxicity (EQ = 8.5). Copper (EQ = 7.4) poses a lesser risk, with an EQ of 7.1 for plant toxicity. Arsenic (EQ = 3.1) poses a significant risk through plant toxicity (EQ = 3.1).

Collectively, these calculated EQs and qualitative observations demonstrate that contaminants at the site constitute probable adverse ecological effects for plants, deer, and aquatic life at the Big Chief-Golconda Mine Site, justifying cleanup measures.

## **5.7 SUMMARY AND CONCLUSIONS**

The field activities for the Big Chief-Golconda Mine Site RI were successful in collecting the data necessary to delineate the nature and extent of waste present at the site, evaluate the reclamation alternatives for this site, and evaluate the risks to human health and the environment. As indicated by the risk analysis, arsenic, cadmium, copper, lead, manganese, and zinc are all present at the Big Chief-Golconda Mine Site at elevated concentrations that pose a slightly unacceptable risk to human health or to the environment.

### **5.7.1 Big Chief-Golconda Mine Site**

Waste rock and soils that have been in contact with the waste rock are the only waste types at the Big Chief-Golconda Mine Site. Stream sediments with elevated concentrations of metals are also present at the site. The following sections discuss each waste type.

#### **Waste Rock**

The Big Chief-Golconda Mine Site contains 6,000 yd<sup>3</sup> of waste rock that should be isolated. No suitably flat upland area of sufficient size is available at the mine site for an on-site repository. An engineered off-site repository could be constructed. Although much of the waste rock at the site does not contain potentially hazardous concentrations of metals (compared with residential and recreational cleanup levels), the waste rock should be isolated from contact with recreational users and stabilized to reduce impacts from erosion and sedimentation to Golconda Creek. The area should be regraded to more gentle and natural slopes that are amenable for reclamation and revegetation. An estimated 3,630 yd<sup>3</sup> of cover soil would be required to provide an 18-inch reclamation soil cover over the 1.5 acres after waste rock has been removed.

#### **Surface Water and Sediment**

The RI indicates that elevated concentrations of metals are not present in the surface water of Golconda Creek. Potential environmental impacts and ecological receptors have been identified during the RI. Removal or isolation of the waste rock near Golconda Creek and selective removal of the streambank materials in the most affected section of Golconda Creek would improve surface water quality. Isolation of the waste rock that contains elevated concentrations of metals should help reduce the amount of metals that enter Golconda Creek over time.

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**RECLAMATION INVESTIGATION AND EVALUATION REPORT  
BIG CHIEF-GOLCONDA MINE, JEFFERSON COUNTY, MONTANA**

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## **6.0 EXPANDED ENGINEERING EVALUATION AND COST ANALYSIS**

### **6.1 INTRODUCTION**

As requested by the Montana Department of Environmental Quality (DEQ), Mine Waste Cleanup Bureau (MWCB), Tetra Tech EM Inc. completed an expanded engineering evaluation/cost analysis (EEE/CA) for the Big Chief-Golconda Mine Site. The EEE/CA presents a detailed analysis of reclamation alternatives that the regulatory agencies can use for decision-making.

The reclamation process has been designed to comply with the requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the Montana Comprehensive Environmental Clean-up and Responsibility Act (CECRA). Certain aspects of the process have been streamlined to meet the regulatory and functional needs of cleaning up relatively small abandoned mine sites that are generally situated in remote locations. The reclamation alternatives considered for implementation at the Big Chief-Golconda Mine site are classified as interim or removal actions and are not necessarily considered the final reclamation remedies or alternatives. In addition, the reclamation alternatives presented in this EEE/CA apply to solid media only; no reclamation alternatives were developed for groundwater or surface water.

The Big Chief-Golconda Mine Site is an abandoned hard rock mine listed on the Montana DEQ/MWCB priorities sites list. The Big Chief-Golconda Mine Site is located 5 miles east of Jefferson City, Montana, in the Alhambra Mining District in Jefferson County, Montana. The mine site is situated at an elevation of 4,980 feet above sea level and consists of 2 acres of disturbed lands, including mine structures, mine openings, and waste rock. Four distinct waste areas and potential contaminated media (surface water, surface soil, subsurface soil, and sediment) are present at this site. Based on a recently completed survey of the site, approximately 5,000 cubic yards (CY) of decomposed granodiorite waste rock and gangue ore are located within the boundary of the site, including erosional remnants of oxidized waste rock piles in Golconda Creek. Minimally contaminated sediments were also identified downstream from the mine site.

### **6.2 RECLAMATION OBJECTIVES AND GOALS**

The overall objective of the reclamation project for the Big Chief-Golconda Mine Site is to protect human health and the environment in accordance with the guidelines set forth by the NCP. Specifically,

reclamation must limit human and ecological exposure to mine-related contaminants and reduce their mobility through the associated solid media, groundwater, and surface water exposure pathways.

As indicated by the risk analysis completed as part of the reclamation investigation (RI) (Section 5) arsenic, copper, lead, manganese, and zinc are present in waste rock at the Big Chief-Golconda Mine Site. Lead and arsenic are present in elevated concentrations that pose an unacceptable risk to human health and the environment.

There are currently no promulgated standards for concentrations of metals in soil. Montana DEQ has, however, developed a conservative set of risk-based guidelines that are calculated for various contaminants using a recreational visitor exposure pathway scenario. The guidelines take into account the possibility of exposure through multiple exposure routes. Action levels for soils at the Big Chief-Golconda Mine Site have therefore been established based on the results of the risk assessment during the RI. The recreational action levels for the metals of concern in soil are listed in Table 5-20.

### **6.3 SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**

Reclamation at the Big Chief-Golconda Mine Site will incorporate federal and state cleanup requirements. The standards, requirements, criteria, or limitations that will be used to reclaim this site are commonly referred to as applicable or relevant and appropriate requirements (ARAR).

Two basic types of reclamation for abandoned mine sites are (1) on-site or off-site disposal (removal) with subsequent revegetation, and (2) in-place amelioration (reclamation) with subsequent revegetation. Removal is designed to eliminate a source of waste from a site and is often conducted to alleviate the most acute or toxic contaminated materials. Amelioration is designed to minimize, stabilize, or mitigate the contaminated materials to ensure a high level of contaminant reduction and to achieve successful reclamation at a site.

ARARs may be either “applicable” or “relevant and appropriate” to reclamation at a site, but not both. Applicable requirements are the standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address hazardous substances, pollutants, contaminants, activities, locations, or other circumstances found at the site. The reclamation actions envisioned should satisfy all the jurisdictional prerequisites of a requirement to be applicable to the specific activity at a site.

Relevant and appropriate requirements are the standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to hazardous substances, pollutants, contaminants, activities, locations, or other circumstances at a site, address problems or situations sufficiently similar to those encountered at a site that their use is well suited to a particular site. Factors that may be considered in making this determination, when the factors are pertinent, are presented in 40 CFR 300.400(g)(2). They include, among other considerations, examination of the purpose of the requirement and of the proposed activity, the medium and substances regulated by the requirement, the regulated actions or activities, and the potential use of resources affected by the requirement.

ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific requirements govern the release of materials that possess certain chemical or physical characteristics or that contain specific chemical compounds to the environment. Contaminant-specific ARARs generally set human or environmental risk-based criteria and protocol that, when applied to site-specific conditions, result in the establishment of numerical action values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location-specific ARARs relate to the geographic or physical position of the site, rather than to the nature of the contaminants. These ARARs restrict the concentration of hazardous substances or the conduct of cleanup because of their location in the environment.

Action-specific ARARs are usually technology- or activity-based requirements or are limitations on actions taken with respect to hazardous substances. A specific activity will trigger an action-specific ARAR. Unlike chemical-specific and location-specific ARARs, action-specific ARARs do not, in themselves, determine the reclamation alternative. Rather, action-specific ARARs indicate how the selected reclamation activity should be completed.

Nonpromulgated advisories or guidance documents issued by federal or state governments do not have the status of potential ARARs. However, these advisories and guidance are “to be considered” (TBC) when determining protective cleanup levels, as defined in 40 Code of Federal Regulations (CFR) 300.400 (g)(3). The TBC category consists of advisories, criteria, or guidance that were developed by the United

States Environmental Protection Agency (EPA), other federal agencies, or states that may be useful in developing reclamation alternatives.

Only those state standards that are more stringent than any federal standard and that have been identified by the state are appropriately included as ARARs. Duplicative or less stringent standards will be deleted as appropriate when the final determination of ARARs is presented.

ARARs are defined as only federal environmental laws and state environmental or facility siting laws. The reclamation methods and operation and maintenance must, nevertheless, comply with all other applicable laws, both state and federal. Many such laws, while not strictly environmental or facility siting laws, have environmental impacts. Moreover, applicable laws that are not ARARs because they are not environmental or facility siting laws are not subject to the ARAR waiver provisions; instead, the applicable provisions of such laws must be observed. A separate list attached to the state ARARs is a noncomprehensive identification of other state law requirements that must be observed during reclamation, operation, and maintenance.

Table 6-1 presents the potential federal ARARs for the Big Chief-Golconda Mine Site. Potential state ARARs are presented in Table 6-2. Appendices F and G provide more complete detailed descriptions of potential federal and state ARARs and their applicability to the Big Chief-Golconda Mine Site. Tables 6-1 and 6-2 summarize the federal and state ARARs descriptions with paraphrased legal requirements, as well as an appendix reference page. In the event of any inconsistency between the law itself and the summaries in this section, the ARAR is ultimately the requirement as set out in the law, rather than the paraphrased requirement provided in Tables 6-1 or 6-2 of this document.

**TABLE 6-1**  
**SUMMARY OF FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<b>Contaminant-Specific</b>				
<u>Clean Air Act</u>	42 USC § 7409			
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Air quality levels that protect public health.	Applicable	F-1
<u>Resource Conservation and Recovery Act</u>		Defines those solid mining-related wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.		
Lists of Hazardous Wastes	40 CFR Parts 261, Subpart D		Applicable	F-2
<u>Clean Water Act</u>	33 USC § 1251-1387	Chapter 26-Water Pollution Prevention and Control.		F-2
Water Quality Standards	40 CFR Part 131 Quality Criteria for Water 1976, 1980, 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate	F-2
National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	General permits for discharge from construction.	Relevant and Appropriate	F-2
<u>Safe Drinking Water Act</u>	40 USC § 300			F-2
National Primary Drinking Water Regulations	40 CFR Part 141	Establishes health-based standards for public water systems (maximum contaminant levels).	Relevant and Appropriate	F-3
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes welfare-based standards for public water systems (secondary maximum contaminant levels).	Relevant and Appropriate	F-3
<b>Location-Specific</b>				
<u>National Historic Preservation Act</u>	16 USC § 470; 36 CFR Part 800 40 CFR 6.310(b)	Requires federal agencies to take into account the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in, or eligible for, inclusion in the National Register of Historic Places to minimize harm to any national historic landmark adversely or directly affected by an undertaking.	Applicable	F-3

**TABLE 6-1 (Continued)**  
**SUMMARY OF FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Archeological and Historic Preservation Act</u>	16 USC § 469; 40 CFR § 6.301(c)	Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	Applicable	F-4
<u>Historic Sites, Buildings, and Antiquities Act</u>	16 USC §§ 461 through 467; 40 CFR 6.301(a)	Requires federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on these landmarks.	Applicable	F-4
<u>Protection of Wetlands Order</u>	40 CFR Part 6	Avoid adverse impacts to wetlands.	Applicable	F-4
<u>Endangered Species Act</u>	16 USC §§ 1531(h) through 1543; 40 CFR Part 6.302; 50 CFR Part 402	Requires action to conserve endangered species within critical habitat on which species depend. Activity may not jeopardize continued existence of endangered species or destroy or adversely modify a critical habitat. Includes consultation with the Department of the Interior.	Applicable	F-5
<u>Resource Conservation and Recovery Act</u>	40 CFR Part 264	Require hazardous waste facilities to be (1) located at least 200 feet from a fault, and (2) designed to withstand a 100-year flood if located in the 100-year flood plain.	Applicable	F-5
<b>Action-Specific</b>				
<u>Hazardous Materials Transportation Act</u>  Standards Applicable to Transport of Hazardous Materials	49 USC §§ 1801-1813  49 CFR Parts 10, 171 through 177	Regulates transportation of hazardous materials including mining wastes that are not exempt under the Bevill Amendment.	Applicable	F-5

**TABLE 6-1 (Continued)**  
**SUMMARY OF FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Resource Conservation and Recovery Act</u>  Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and, thereby, constitute prohibited open dumps.	Applicable	F-6
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards that apply to persons transporting hazardous waste within the United States if the transportation requires a manifest under 40 CFR Part 262.	Applicable	F-6
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards that define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable	F-6
<u>Clean Water Act</u>  National Pollutant Discharge Elimination System	33 USC § 1342  40 CFR Part 122	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate	F-8
<u>Surface Mining Control and Reclamation Act</u>	30 USC §§1201 through 1326 30 CFR Part 816; 30 CFR Part 784	Protects the environment from effects of surface coal mining operations.	Relevant and Appropriate	F-8

**TABLE 6-2**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<b>Contaminant-Specific</b>				
<u>Montana Water Quality Act</u>	§ 75-5-101 <u>et seq.</u> , MCA ARM 17.30.601 <u>et seq.</u>	Promulgates regulations to protect, maintain, and improve the quality of surface waters in the state. Montana's regulations classify state waters according to quality, restrict the discharge of pollutants to state waters, and prohibit degradation of state waters.	Applicable	G-1
	ARM 17.30.637	Provides that surface water must be free of substances attributable to industrial practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable taste to fish flesh or make fish inedible; (d) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions that produce undesirable aquatic life. In addition, no waste may be discharged and no activities conducted which, either alone or in combination with other waste activities, will violate surface water quality standards; provided a short-term exception from a surface water quality standard may be authorized by the department under certain conditions.	Applicable	G-1

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
Montana Groundwater Pollution Control System	ARM 17.30.1006	<p>Classifies groundwater into Classes I through IV based on its specific conductance and establishes the groundwater quality standards applicable with respect to each groundwater Classification.</p> <p>If determined to be Classes I through III groundwater based on its specific conductance, the groundwater at the site must meet the beneficial uses and standards for that class. Concentrations of substances in groundwater within these classes may not exceed the human health standards for groundwater listed in department Circular WQB-7. In addition, no increase of a parameter may violate § 75-5-303 MCA, (nondegradation). For concentrations of parameters where human health standards are not listed in WQB-7, ARM 17.30.1006 allows no increase of a parameter to a level that renders the waters harmful, detrimental or injurious to the beneficial uses listed for that class of water. For standards for Class IV groundwater, see ARM 17.30.1006.</p>	Applicable	G-2
	ARM 17.30.1011	<p>Provides that any groundwater where the existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with § 75-5-303 MCA, and ARM Title 17, Chapter 30, Subchapter 7.</p>	Applicable	G-2

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
Air Quality Regulations	ARM 17.8.206	Establishes sampling, data collection, and analytical requirements to ensure compliance with ambient air quality standards.	Applicable	G-2
	ARM 17.8.220	Settled particulate matter shall not exceed a 30-day average of 10 grams per square meter.	Applicable	G-3
	ARM 17.8.222	Lead emissions to ambient air shall not exceed a 90-day average of 1.5 micrograms per cubic liter of air.	Applicable	G-3
	ARM 17.8.223	PM <sub>10</sub> concentrations in ambient air shall not exceed a 24 hour average of 150 micrograms per cubic meter of air and an annual average of 50 micrograms per cubic meter of air.	Applicable	G-3
	ARM 17.8.210 – 214	Ambient air standards are also promulgated for carbon dioxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. These standards would also apply if emissions of these compounds were to occur at the site in connection with any response action.	Applicable	G-3
<b>Location-Specific</b>				
Endangered Species	§§ 87-5-106, 107, and 111, MCA	Endanger species should be protected to maintain and, to the extent possible, enhance their numbers. These sections list endangered species, prohibited acts, and penalties.	Applicable	G-3
	§§ 87-5-106 and 201, MCA	Describes protection of wild birds, nests, and eggs.	Applicable	G-3
	ARM 12.5.201	Lists certain activities that are prohibited with respect to specified endangered species.	Applicable	G-3

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Flood Plain and Floodway Management Act and Regulations</u>	§ 76-5-401, et seq., MCA ARM 36.15.601	Specifies types of uses and structures that are allowed or prohibited in the designated 100-year floodway and floodplain. Uses prohibited anywhere in either the floodway or the floodplain are: (1) solid and hazardous waste disposal; and (2) storage of toxic, flammable, hazardous, or explosive materials.	Relevant and Appropriate	G-3
	ARM 36.15.605(2), 36.15.703, and 36.15.602(5)(b)	These provisions effectively prohibit the placement of mine waste repositories within the 100-year floodplain and require that mine wastes addressed in response actions be removed from the floodplain. In the floodway, additional provisions apply, including prohibition of: (1) a building for living purposes or place of assembly or permanent use by human beings; (2) any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; and (3) the construction or permanent storage of an object subject to flotation or movement during flood level periods.	Relevant and Appropriate	G-4
	§ 76-5-402, MCA	Specifies factors that must be considered in allowing diversions of the stream, changes in place of diversion of the stream, flood control works, new construction or alteration of artificial obstructions, or any other nonconforming use within the floodplain or floodway.	Relevant and Appropriate	G-4
	§ 76-5-406, MCA ARM 36.15.216	Conditions or restrictions that generally apply to specific activities within the floodway or floodplain are: (1) the proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount or significantly increase flood velocities; and (2) the proposed activity, construction, or use must be designated and constructed to minimize potential erosion.	Relevant and Appropriate	G-4

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Flood Plain and Floodway Management Act and Regulations</u> (continued)	Miscellaneous	See the following applicable regulations for the substantive conditions and restrictions applicable to specific obstructions or uses:  Excavation of material from pits or pools – ARM 36.15.602(1)  Water diversions or changes in place of diversion – ARM 36.15.603  Flood control works (levees, floodwalls, and riprap must comply with specified safety standards) – ARM 36.15.606  Road, streets, highways, and rail lines (must be designed to minimize increases in flood heights) – ARM 36.15.701(3)(c).  Structures and facilities for liquid or solid waste treatment and disposal (must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with DEQ regulations, which include certain additional prohibitions on such disposal) – ARM 36.15.701(3)(d).  Residential structures – ARM 36.15.702(1)  Commercial or industrial structures – ARM 36.15.702(2)	Relevant and Appropriate	G-4
			Relevant and Appropriate	G-5
<u>Montana Natural Streambed and Land Preservation Act</u>	§ 75-7-102, MCA and ARM 36.2.405, 406, and 410	Applicable if a response action alters or affects a streambed or its banks. The adverse effects of any such action must be minimized.	Applicable	G-5
	ARM 36.2.410	Establishes minimum standards that would be applicable if a response action alters or affects a streambed, including any channel change, new diversion, riprap, or other streambank protection project, jetty, new dam or reservoir or other commercial, industrial, or residential development.	Applicable	G-5

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Solid Waste Management Act</u>	§ 75-10-201, <u>et seq.</u> , MCA and ARM 17.50.505(1)	Regulations promulgated under the Solid Waste Management Act, § 75-10-201 <u>et seq.</u> , MCA, specify requirements that apply to location of any solid waste management facility.	Applicable	G-5
	ARM 17.50.505	Provides that a facility for the treatment, storage or disposal of solid wastes: (1) must be located where sufficient acreage of suitable land is available for solid waste management; (2) may not be located in a 100-year floodplain; (3) may be located only in areas that will prevent the pollution of groundwater and surface waters and public and private water supply systems; (4) must be located to allow for reclamation and reuse of the land; (5) drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and (6) where underlying geological formations contain rock fractures or fissures which may lead to pollution of the groundwater or areas where springs exist that are hydraulically connect to a proposed disposal facility, only Class III disposal facilities (that contain completely inert wastes) may be approved.	Applicable	G-5
	§ 75-10-212, MCA	Prohibits dumping or leaving any debris or refuse on or within 200 yards of any highway, road, street, or alley of the state or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted. However, the restriction relating to privately owned property does not apply to the owner, his agents, or those disposing of debris or refuse with the owner's consent.	Applicable	G-5

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<b>Action-Specific</b>				
<u>Groundwater Act</u>	MCA § 85-2-505	Precludes the wasting of groundwater. Any well producing waters that contaminate other waters must be plugged or capped, and wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater.	Applicable	G-6
	MCA § 85-2-516	States that a well log report must be filed by the driller with the DNRC and the appropriate county clerk and recorder within 60 days after any well is completed.	Applicable	G-6
	ARM 17.30.641	Provides standards for sampling and analysis of water to determine quality.	Applicable	G-6
	ARM 17.30.646	Requires that bioassay tolerance concentrations be determined in a specified manner.	Applicable	G-6
	ARM 36.21.670-678 and 810	Specifies certain requirements that must be fulfilled when abandoning monitoring wells.	Applicable	G-6
Montana Pollutant Discharge Elimination System (MPDES) Permit Requirements	ARM 17.30.1342-1344	Sets forth the substantive requirements to all MPDES and NPDES permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.	Applicable	G-6
Technology-Based Treatment	ARM 17.30.1203 and 1344	Technology-based treatment for MPDES permits.	Applicable	G-6
<u>Montana Water Quality Act</u> – Causing of Pollution	§ 75-5-605(1)(a), MCA	Prohibits the causing of pollution of any state waters. Pollution is defined as contamination or other alteration of physical, chemical, or biological properties of state waters that exceed that permitted by the water quality standards. Also, it is unlawful to place or caused to be placed any wastes where they will cause pollution of state waters.	Applicable	G-6

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
Nondegradation of Water Quality	§ 75-5-303, MCA	States that existing uses of state waters and the level of water quality necessary to protect the users must be maintained and protected.	Applicable	G-8
	§ 75-5-317, MCA	Provides an exemption from nondegradation requirements that allows changes of existing water quality resulting from an emergency or remedial activity that is designed to protect the public health or environment and that is approved, authorized, or required by the department. Degradation meeting these requirements may be considered nonsignificant. In determining that remedial actions are protective of public health and the environment and in approving, authorizing, or requiring such remedial activities, no significant degradation should be approved.	Applicable	G-8
	17.30.705	Provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.708.	Applicable	G-8
	17.30.1011	Provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation may be allowed under the principles established in § 75-5-303, MCA, and the nondegradation rules at ARM 17.30.701, <u>et seq.</u>	Applicable	G-8

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
Storm Water Runoff	ARM 17.30.1332 and 1341	Requires a Storm Water Discharge General Permit for storm water point sources. Generally, the permits require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge that has a reasonable likelihood of adversely affecting human health and the environment. However, additional protection may be required if there is evidence indicating potential or realized impacts on water quality as a result of any storm water discharge associated with the activity.	Applicable	G-8
	ARM 17.24.633	All surface drainage from a disturbed area must be treated by the best technology available.	Applicable	G-8
	ARM 17.30.637	Prohibits discharges containing substances that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or on adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions that create a nuisance or render undesirable taste to fish flesh or make fish inedible; (d) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.	Applicable	G-8
<u>Montana Hazardous Waste Act – State RCRA Subtitle C Requirements</u>	§ 75-10-401 et seq., MCA and ARM Title 17, Chapter 54	Establishes a regulatory structure for the generation, transportation, treatment, storage, and disposal of hazardous wastes.	Applicable	G-9

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Solid Waste Act – State RCRA Subtitle D Requirements</u>	§ 75-10-201 <u>et seq.</u> , MCA	Establishes requirements that are applicable to the management and disposal of solid wastes, including mine wastes at sites that are not currently subject to operating permit requirements.	Applicable	G-9
	ARM 17.50.505	Sets forth standards that all solid waste disposal sites must meet, including the requirements that (1) Class II landfills must confine solid waste and leachate to the disposal facility. If there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters; (2) adequate separation of group II wastes from underlying or adjacent water must be provided; and (3) no new disposal units or lateral expansions may be located in wetlands. This section also specifies general soil and hydrogeologic requirements pertaining to the location of any solid waste management facility.	Applicable	G-9
	ARM 17.50.506	Specifies design requirements for landfills. Landfills must either be designed to ensure that MCLs are not exceeded, or the landfill must contain a composite liner and leachate collection system which comply with specified criteria.	Applicable	G-9
	ARM 17.50.511	Set forth general operational and maintenance and design requirements for solid waste facilities using land filling methods. Specific operational and maintenance requirements specified in this section that are applicable are run-on and run-off control systems requirements, requirements that sites be fenced to prevent unauthorized access, and prohibitions of point source and nonpoint source discharges which would violate Clean Water Act requirements.	Applicable	G-9
	ARM 17.50.523	Specifies that solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Applicable	G-9

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Solid Waste Act – State RCRA Subtitle D Requirements</u> (continued)	ARM 17.50.530	Sets forth the closure requirement for landfills. Class II landfills must meet the following criteria: (1) install a final cover that is designed to minimize infiltration and erosion; (2) design and construct the final cover system to minimized infiltration through the closed unit by the use of an infiltration layer that contains a minimum of 18 inches of earthen material and has a permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoils or a permeability of no greater than 1 x 10 <sup>-5</sup> cm/sec, whichever is less; (3) minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of 6 inches of earthen material that is capable of sustaining native plant growth and protecting the infiltration layer from frost effects and rooting damage; and (4) revegetate the final cover with native plant growth within one year of placement of the final cover.	Applicable	G-9
	ARM 17.50.531	Sets forth post-closure care requirements for Class II landfills. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post-closure care requires maintenance of the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cover and comply with the groundwater monitoring requirements found at ARM Title 17, Chapter 50, Subchapter 7.	Applicable	G-9
	§ 75-10-206, MCA	Allows variances to be granted from certain solid waste regulations if failure to comply with the rules does not result in danger to public health and safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship.	Applicable	G-9

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Strip and Underground Mine Reclamation Act and Montana Metal Mining Act</u>         <u>Montana Metal Mine Reclamation Act</u>	§ 82-4-201 <u>et seq.</u> , MCA and § 82-4-301 <u>et seq.</u> , MCA	Certain portions of the following statutory or regulatory provisions are relevant and appropriate requirements.	Relevant and Appropriate	G-10
	§ 84-2-231, MCA	Requires operators to reclaim and revegetate affected lands using the most modern technology available. Operators must grade, backfill, cover with topsoil, reduce high walls, stabilize subsidence, control water, minimize erosion, subsidence, land slides, and water pollution.	Relevant and Appropriate	G-10
	§ 84-2-233, MCA	Operators must plant vegetation that will yield a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of self-generation.	Relevant and Appropriate	G-10
	§ 82-4-336, MCA	Disturbed areas must be reclaimed to utility and stability comparable to adjacent areas.	Relevant and Appropriate	G-10
	ARM 17.24.501(3)(a) and (d) and (4)	Backfill must be placed so as to minimize sedimentation, erosion, and leaching of acid or toxic materials into waters, unless otherwise approved.	Relevant and Appropriate	G-10
	ARM 17.24.501 (A)(1)(a) and (2)	Final graded slopes will be 5:1 unless otherwise approved. If steeper, slopes must have a long term static safety factor of 1:3, not to exceed the angle of repose unless the existing grade of the area is steeper, in which case the existing grade meets this requirements. Disturbed areas must be blended with undisturbed ground to provide a smooth transition in topography.	Relevant and Appropriate	G-10
	ARM 17.24.514	Final grading will be done along the existing contour in order to minimize subsequent erosion and instability, unless otherwise approved.	Relevant and Appropriate	G-10
	ARM 17.24.519	Pertinent areas where excavation will occur will be regraded to minimize settlement.	Relevant and Appropriate	G-10

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Metal Mine Reclamation Act</u> (continued)	ARM 17.24.631(1), (2), (3)(a), and (b)	Disturbances to the prevailing hydrologic balance will be minimized. Changes in water quality and quantity, in the depth to groundwater and in the location of surface water drainage channels will be minimized, to the extent consistent with the selected response alternatives. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.	Relevant and Appropriate	G-10
	ARM 17.24.633	Surface drainage from a disturbed area must be treated by the best technology currently available (BCTA). Treatment must continue until the area is stabilized.	Relevant and Appropriate	G-11
	ARM 17.24.634	Disturbed drainages will be restored to the approximate pre-disturbance configuration, to the extent consistent with the response alternatives selected. Drainage design must emphasize channel and floodplain dimensions that approximate the pre-mining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to: (1) meander naturally; (2) remain in dynamic equilibrium with the system; (3) improve unstable pre-mining conditions; (4) provide for floods; and (5) establish a pre-mining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate	G-11
	ARM 17.24.635 – 637	Sets forth requirements for temporary and permanent diversions.	Relevant and Appropriate	G-11
	ARM 17.24.638	Sediment control measures must be implemented during operation.	Relevant and Appropriate	G-11

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Metal Mine Reclamation Act</u> (continued)	ARM 17.24.639	Sets forth requirements for construction and maintenance of sedimentation ponds.	Relevant and Appropriate	G-11
	ARM 17.24.640	Discharges from sedimentation ponds and permanent and temporary impoundments must be controlled to reduce erosion and enlargement of stream channels, and to minimize disturbance of the hydrologic balance.	Relevant and Appropriate	G-11
	ARM 17.24.641	Practices to prevent drainage of acid or toxic forming spoil material into ground and surface water will be employed.	Relevant and Appropriate	G-11
	ARM 17.24.643 – 646	Provisions for groundwater protection, groundwater recharge protection, and groundwater and surface water monitoring.	Relevant and Appropriate	G-11
	ARM 17.24.701 and 702	Requirements for redistributing and stockpiling of soil for reclamation. Also outlines practices to prevent compaction, slippage, erosion, and deterioration of biological properties of soil will be employed.	Relevant and Appropriate	G-11
	ARM 17.24.703	When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation.	Relevant and Appropriate	G-11
	ARM 17.24.711	Requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety and utility as the vegetation native to the area of land to be affected must be established.	Relevant and Appropriate	G-11
	ARM 17.24.713	Disturbed areas must be seeded and planted during the first appropriate period for favorable planting after final seedbed preparation but may not be more that 90 days after soil has been replaced.	Relevant and Appropriate	G-11

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Metal Mine Reclamation Act</u> (continued)	ARM 17.24.714	Mulch and cover crop or both must be used until adequate permanent cover can be established.	Relevant and Appropriate	G-12
	ARM 17.24.716	Establishes method of revegetation.	Relevant and Appropriate	G-12
	ARM 17.24.717	Relates to the planting of trees and other woody species if necessary to establish a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the affected area and capable of self-generation and plant succession at least equal in extent of cover to the natural vegetation of the area, except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved intended land use plan.	Relevant and Appropriate	G-12
	ARM 17.24.718	Requires soil amendments, irrigation, management, fencing, or other measures, if necessary, to establish a diverse and permanent vegetative cover.	Relevant and Appropriate	G-12
	ARM 17.24.721	Specifies that rills or gullies deeper than 9 inches must be stabilized. In some instances shallower rills and gullies must be stabilized.	Relevant and Appropriate	G-12
	ARM 17.24.723	States that operators shall conduct approved periodic measurements of vegetation, soils, water, and wildlife during the period of liability.	Relevant and Appropriate	G-12
	ARM 17.24.724	Specifies that revegetation success must be measured by approved unmined reference areas. There must be at least one reference area for each plant community type. Required management for these reference areas is set forth.	Relevant and Appropriate	G-12
	ARM 17.24.726	Sets the required methods for measuring productivity.	Relevant and Appropriate	G-12

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
<u>Montana Metal Mine Reclamation Act</u> (continued)	ARM 17.24.728	Sets requirements for measurements of permanence of vegetation on reclaimed areas.	Relevant and Appropriate	G-12
	ARM 17.24.730 and 731	Provide that the revegetated area must furnish palatable forage in comparable quantity and quality during the grazing period as the reference area. If toxicity to plants or animals is suspected, comparative chemical analyses may be required.	Relevant and Appropriate	G-12
	ARM 17.24.733	Provides additional requirements and measurement standards for trees, shrubs, and half-shrubs.	Relevant and Appropriate	G-12
	ARM 17.24.751	Measures to prevent degradation of fish and wildlife habitat will be employed.	Relevant and Appropriate	G-12
	ARM 17.24.761	Specifies fugitive dust control measures that will be employed during excavation and construction to minimize emissions of fugitive dust.	Relevant and Appropriate	G-12
Air Quality Requirements	ARM 17.8.308(2), (3), and (4)	Airborne particulate matter. There shall be no production, handling, transportation, or storage of any material, used of any street, road, parking lot, or operation of a construction site or demolition project, unless reasonable precautions are taken to control emissions of airborne particles. Emissions shall not exhibit an opacity exceeding 20 percent or greater averaged over 6 consecutive minutes.	Applicable	G-13
	ARM 17.8.604	Lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste that is moved from the premises where it was generated and any trade material may be open burned only in accordance with the substantive requirements of ARM 17.8.611 and 612.	Applicable	G-13

**TABLE 6-2 (Continued)**  
**SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**  
**BIG CHIEF-GOLCONDA MINE SITE**

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable Relevant and Appropriate	Appendix Page Reference
Air Quality Requirements (continued)	ARM 17.8.304(2)	Visible air contaminants. Emissions into the outdoor atmosphere shall not exhibit opacity of 20 percent or greater averaged over 6 consecutive minutes.	Applicable	G-13
	ARM 17.8.308	Requires that any new source of airborne particulate matter that has the potential to emit less than 100 tons per year of particulates shall apply best available control technology (BACT); any new source of airborne particulate matter that has the potential to emit more than 100 tons per year of particulates shall apply lowest achievable emission rate (LAER).	Applicable	G-13
	ARM 17.8.315(1)	Nuisance or odor bearing gases. Gases, vapors and dusts will be controlled such that no public nuisance is caused.	Applicable	G-13
	ARM 17.24.761(2)(a), (e), (h), (j), and (k)	Fugitive dust control measures such as (1) watering, stabilization, or paving of roads, (2) vehicle speed restrictions, (3) stabilization of surface areas adjoining roads, (4) restriction of travel on other than authorized roads, (5) enclosing, covering, watering, or otherwise treating loaded haul trucks, (6) minimizing area of disturbed land, and (7) revegetation, must be planned and implemented, if any such measures are appropriate for this response action.	Applicable	G-13
Noxious Weeds	§ 7-22-21001(7)(a), MCA	Defines “noxious weeds” as any exotic plant species established or that may be introduced in the state that may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities and that is designated: (i) as a statewide noxious weed by rule of the department; or (ii) as a district noxious weed by a board, following public notice of intent and a public hearing. Designated noxious weeds are listed in ARM 4.5.201 through 204 and must be managed consistent with weed management criteria developed under § 7-22-2109(2)(b), MCA.	Applicable	G-14

## **6.4 IDENTIFICATION AND SCREENING OF RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS**

The appropriate reclamation alternatives for the Big Chief-Golconda Mine Site will be selected based on the following: (1) the waste location; (2) the concentration of metals and other contaminants in the waste materials; (3) the volume of waste materials; and (4) the applicability of the reclamation alternatives.

Alternatives are developed and subjected to three phases of screening or evaluation during the reclamation selection process. These phases include initial screening, alternative screening, and detailed analysis (EPA 1988). The results of the initial and alternative screening selection process for the Big Chief-Golconda Mine Site are described in Sections 6.4 and 6.5. The detailed and comparative analysis of the reclamation alternatives is presented in Sections 6.6 and 6.7.

### **6.4.1 Identification and Initial Screening of Reclamation Alternatives**

The first step in the process for developing and analyzing reclamation alternatives for the Big Chief-Golconda Mine Site is identifying and describing general response actions that may satisfy the reclamation objectives. General response actions are then progressively refined into technology types and process options. The process options are then screened, and the technologies and process options retained are combined into potential media-specific reclamation alternatives.

After the potential reclamation alternatives have been identified, they are subjected to initial screening, which is the first step in the alternative selection process. The initial screening eliminates options that are not feasible from further consideration and retains the options that are potentially feasible. In addition, general response actions, technologies, and process options are evaluated for contaminated solid media only. No technologies have been evaluated for surface water or groundwater for the Big Chief-Golconda Mine Site. This decision was based primarily on the assumption that reclaiming the contaminated source materials will subsequently reduce any impacts to surface water and groundwater at the site. Separate, feasible reclamation alternatives may exist for each waste type and waste area found at the mine site.

General response actions, technologies, and process options potentially capable of meeting the reclamation objectives for the solid media at the Big Chief-Golconda Mine Site are identified in Table 6-3. Response actions include no action, institutional controls, engineering controls, excavation and treatment, and in place treatment. The following paragraphs describe the results of the initial screening of the general response actions, technologies and process options for the Big Chief-Golconda Mine Site.

**TABLE 6-3**  
**GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS**  
**SOLID MEDIA**  
**BIG CHIEF-GOLCONDA MINE SITE**

General Response Action	Technology Type	Process Options
No Action	None	None
Institutional Controls	Access Restrictions	Fencing/Barrier
Engineering Controls	Surface Controls	Consolidation
		Grading
		Revegetation/Erosion Protection
	Containment	Earthen Cover
		Earthen and Geomembrane Cap
	On-Site Disposal	Earthen Cover
		Earthen and Geomembrane Cap
		Modified RCRA Subtitle C Repository
		RCRA Subtitle C Repository
	Off-Site Disposal	Solid Waste Landfill
		RCRA Subtitle C Landfill
Excavation and Treatment	Fixation/Stabilization	Cement/Silicates
	Reprocessing	Milling/Smelting
	Physical/Chemical Treatment	Soil Washing
		Acid Extraction
		Alkaline Leaching
	Thermal Treatment	Rotary Kiln
		Vitrification
In-Place Treatment	Physical/Chemical Treatment	Soil Flushing
		Stabilization
		Dewatering
	Thermal Treatment	Vitrification

#### **6.4.1.1 No Action**

Under the no action option, no reclamation actions would occur at the Big Chief-Golconda Mine Site. The no action response is a stand-alone response that is used as a baseline for comparison with other reclamation alternatives. The no action alternative will be retained through the detailed analysis of alternatives.

#### **6.4.1.2 Institutional Controls**

Institutional controls can be used to protect human health and the environment by precluding future access to, or development of, affected areas. In addition, these restrictions may be used to protect an implemented remedy. Potentially applicable institutional controls consist of access restrictions. Access restrictions typically include physical barriers, such as fencing, that could prevent both human and wildlife access to the site to preclude exposure to contamination and to protect the integrity of the remedy.

Institutional controls could be implemented as a stand-alone remedy or in combination with other alternatives. The local government would likely enforce institutional controls that are developed as part of an alternative for the Big Chief-Golconda Mine Site. Therefore, these entities must be involved in developing and eventually implementing any institutional controls.

This type of action does not, in itself, achieve a specific cleanup goal. Considering the baseline risks posed by contaminants at the Big Chief-Golconda Mine Site, institutional controls alone are not considered adequate to mitigate these potential human health and ecological risks. However, institutional controls will be considered in conjunction with other reclamation alternatives.

#### **6.4.1.3 Engineering Controls**

Engineering controls are used primarily to reduce the mobility of, and exposure to, contaminants. These goals are accomplished by creating a barrier that prevents direct exposure and transport of waste from the contaminated source to the surrounding media. Engineering controls do not reduce the volume or toxicity of the hazardous material. Engineering controls typically applied include containment/capping, revegetation, runoff/runoff control, and disposal in a repository. These engineering controls are discussed in the following subsections.

## **Surface Controls**

Surface control measures are used primarily to reduce contaminant mobility and limit direct exposure. Surface controls may be appropriate in more remote areas where direct human contact is not a primary concern (in other words, where human receptors are not living or working directly on or near the site). Surface control process options include consolidation, grading, revegetating, and erosion protection. These process options are usually integrated as a single reclamation alternative.

Consolidation involves grouping similar waste types in a common area for subsequent management or treatment. Excavation during consolidation is accomplished with standard earthmoving equipment, including scrapers, bulldozers, excavators, loaders, and trucks. Consolidation is especially applicable when multiple waste sources are present at a site and one or more of the sources requires removal from particularly sensitive areas (that is, floodplain or heavy traffic). It also may be especially applicable when one large combined waste source is treated in a particular location, rather than several smaller waste sources dispersed throughout an area. Precautionary measures, such as temporary stream diversion or isolation, would be necessary for excavating materials contained in the small drainages at the site. Containment and treatment of water encountered during excavation may also be necessary.

Grading is the general term for techniques used to reshape the ground surface to reduce slopes, manage surface water infiltration and runoff, and aid in erosion control. The spreading and compaction steps used in grading are routine construction practices. The equipment and methods used in grading are similar for all surfaces, but will vary slightly depending on the waste location and the surrounding terrain. Equipment may include bulldozers, scrapers, graders, and compactors. Periodic maintenance and regrading may be necessary to eliminate depressions formed as a result of settlement, subsidence, or erosion.

Revegetation involves adding soil amendments to the waste surface to provide nutrients, organic material, and neutralizing agents and improve the water storage capacity of the contaminated media, as necessary. Revegetation will provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion and reduces net infiltration through the contaminated medium by increasing evapotranspiration processes. Revegetation can also reduce the potential for direct contact. In general, revegetation includes the following steps: (1) selecting appropriate plant species, (2) preparing the seed bed, which may include deep application of soil amendments to provide acid buffering and enhance vegetation, as necessary, (3) seeding and planting, and (4) mulching and chemical fertilizing.

Erosion protection includes using erosion-resistant materials, such as mulch, natural or synthetic fabric mats, riprap, and surface water diversion ditches to reduce the erosion potential at the surface of the contaminated medium. The erosion-resistant materials are placed in areas susceptible to surface water erosion (concentrated flow or overland flow) or wind erosion. Proper erosion protection design requires knowledge of the characteristics of the drainage area, average slopes, soil texture, vegetation types and abundance, and precipitation data.

Surface controls are considered a feasible option for all waste types at the Big Chief-Golconda Mine Site and will be retained for further consideration as a reclamation alternative, or in conjunction with other alternatives.

### **Containment**

A containment approach leaves waste materials in place and uses capping to reduce or eliminate exposure to, and mobility of, contaminated medium. Containment source control measures can be used to divert surface water from the contaminated medium and to minimize infiltration (and subsequent formation of leachate) of surface water and precipitation into the underlying contaminated medium. Infiltration can be reduced or prevented by physical barriers or by increasing evapotranspiration processes. The physical capping or covering of wastes during containment reduces or eliminates the potential health risk that may be associated with exposure (direct contact or airborne releases of particulates) to the contaminated media.

The design of the cap or cover may vary in complexity from a simple earthen cover to a multilayered cap designed to meet Resource Conservation and Recovery Act (RCRA) requirements. Factors to consider in design of the cap or cover include physical conditions of the contaminated media, leachability, site hydrogeology, precipitation, depth to groundwater, current groundwater quality, area groundwater use, and applicable groundwater standards. Stringent performance standards may not always be appropriate for the cap, particularly where the toxicity of the contaminated medium is relatively low, where the cap is intended to be temporary, where there is low precipitation, or where the waste is not leached by infiltrating rain water. Specific cap design should also consider the desired land use after construction.

Containment is considered a standard construction practice. Equipment and construction methods associated with containment are readily available, and design methods and requirements are well understood.

Containment is considered a feasible option for all waste types at the Big Chief-Golconda Mine Site and will be retained for further consideration as a reclamation alternative or in combination with other alternatives.

### **On-Site Disposal**

Permanent, on-site disposal is used as a source control measure and is similar to containment. The objectives of on-site disposal are the same as for containment, except that disposal includes excavation and consolidation of waste into a single, usually smaller area, and may involve installing physical barriers beneath as well as above the waste. This added barrier may be needed to provide additional protection of groundwater from potential leachate contamination.

On-site disposal options may be applied to treated or untreated contaminated materials. Treatment may become a cost-effective option as materials are excavated and moved during this process. The design configuration of an on-site repository would depend on the toxicity and type of material that requires disposal. The design could range in complexity from an earthen cover, an earthen cap with geomembrane liner, a modified RCRA Subtitle C repository, or a RCRA Subtitle C repository.

Factors to consider in design include the physical condition of the contaminated media, leachability, site hydrogeology, precipitation, depth to groundwater, current groundwater quality, area groundwater use, and applicable groundwater standards. Stringent performance standards may not always be appropriate for the cap, particularly where the toxicity of the contaminated medium is relatively low, where there is very low precipitation, or where the waste is not leached by infiltrating rain water. Desired land use after construction should also be considered in design of the cap.

Steep slopes in waste rock dump areas may require use of specialized equipment or construction methods. Precautionary measures, such as stream diversion or isolation, would be necessary for excavating materials contained in the small drainage on site. Containment and treatment of water encountered during excavating and drying excavated material may also be necessary.

A potential on-site repository area has been identified during the reclamation investigation. Therefore, on-site disposal options will be retained for further evaluation.

## **Off-Site Disposal**

Off-site disposal involves placing excavated contaminated material in an engineered containment facility located outside the boundary of the site. Off-site disposal options may be applied to pretreated or untreated contaminated materials. Materials that fail to meet the Toxicity Characteristic Leaching Procedure (TCLP) criteria, if disposed of off site, would require disposal in a RCRA-permitted treatment, storage, and disposal (TSD) facility. Conversely, less toxic materials could be disposed of in an off-site mine waste repository or in a permitted sanitary landfill in compliance with other applicable laws.

Excavation and disposal at an off-site RCRA hazardous waste landfill is considered too costly as an alternative for all mine wastes at the Big Chief-Golconda Mine Site. However, disposal of wastes in a mine waste repository located at the Washington Mine site repository, located 10 miles west of the site, or at Leach Pad #1, located 20 miles northwest of the site, will be considered as part of this EEE/CA. The closest RCRA hazardous waste landfill locations are in Utah, Idaho, and Oregon. Off-site disposal in a RCRA hazardous waste landfill will be retained only for mill and smelter wastes that may not be Bevill exempt; however, no hazardous waste has yet been identified at the site.

### **6.4.1.4 Excavation and Treatment**

Excavation and treatment incorporate the removal of contaminated media and subsequent treatment via a specific treatment process that chemically, physically, or thermally results in a reduction in the toxicity and volume of the contaminant. Treatment processes have the primary objective of either: (1) concentrating the metal contaminants for additional treatment or recovery of valuable constituents, or (2) reducing the toxicity of the hazardous constituents.

Excavation can be completed using conventional earth-moving equipment and accepted hazardous materials handling procedures. Precautionary measures, such as stream diversion or isolation, would be necessary for excavating materials contained in the small drainages on the site. Containment and treatment of water encountered during excavation may also be necessary.

## **Fixation and Stabilization**

Fixation and stabilization technologies are used to treat materials by physically encapsulating them in an inert matrix (stabilization) and chemically altering them to reduce the mobility and toxicity of their

constituents (fixation). These technologies generally involve mixing materials with binding agents under prescribed conditions to form a stable matrix. Fixation and stabilization are established technologies for treating inorganic contaminants. The technologies incorporate a reagent or combination of reagents to facilitate a chemical and physical reduction of the mobility of contaminants in the solid media. Lime/fly ash-based treatment processes and pozzolan/cement-based treatment processes are potentially applicable fixation and stabilization technologies.

Excavation and subsequent fixation and stabilization treatment are not considered feasible options for the Big Chief-Golconda Mine Site because the large volume of waste makes the treatment cost prohibitive. Other feasible options can provide equal protectiveness.

### **Reprocessing**

Reprocessing involves excavating and transporting the waste materials to an existing permitted mill or smelter facility for processing and economic recovery of target metals. Applicability of this option depends on market prices of the target metals and the willingness of an existing permitted facility to accept and process the material and dispose of the waste. Although metals have been reprocessed at active facilities in the past, permit limitations, CERCLA liability, and process constraints all limit the feasibility of this process option.

At this time, reprocessing is not considered feasible for the material at this site based on the lack of an available reprocessing facility and the expected high cost of transportation and reprocessing. Reprocessing could become feasible in the future, however, depending on market conditions and the availability of a suitable reprocessing facility. This process is not being carried forward for detailed analysis since other options can provide equal protectiveness.

### **Physical and Chemical Treatment**

Physical treatment processes concentrate constituents into a relatively small volume for disposal or further treatment. Chemical treatment processes act through the addition of a chemical reagent that removes or fixates the contaminants. The net result of chemical treatment processes is a reduction of toxicity and mobility of contaminants in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the contaminated media with water, acids, bases, or

surfactant. Potentially applicable physical and chemical treatment process options include soil washing, acid extraction, and alkaline leaching.

Soil washing is an innovative treatment process that consists of washing the contaminated medium with water in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires that contaminants be readily soluble in water and sized sufficiently small so that dissolution can be achieved in a practical retention time. Dissolved metal constituents contained in the wash solution are precipitated as insoluble compounds, and the treated solids are dewatered before additional treatment or disposal. The precipitates form a sludge that would require additional treatment, such as dewatering or stabilization, before disposal.

Acid extraction applies an acidic solution to the contaminated medium in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of the metal constituents in the contaminated medium would be solubilized. A broader range of contaminants can be expected to be acid soluble at ambient conditions using acid extraction versus soil washing; however, sulfide compounds may be acid soluble only under extreme conditions of temperature and pressure. Dissolved contaminants are subsequently precipitated for additional treatment and disposal.

Alkaline leaching is similar to acid extraction in that a leaching solution (in this case, ammonia, lime, or caustic soda) is applied to the contaminated medium in a heap, vat, or agitated vessel. Alkaline leaching is potentially effective for leaching most metals from the contaminated media; however, removal of arsenic is not well documented.

Excavation and subsequent physical and chemical treatment are not considered feasible options because the large volume of waste makes treatment cost prohibitive. Other feasible options can provide equal protectiveness.

### **Thermal Treatment**

Under thermal treatment technologies, heat is applied to the contaminated medium to volatilize and oxidize metals and render them amenable to additional processing and to vitrify the contaminated medium into a glass-like, nontoxic, nonleachable matrix. Potentially applicable moderate-temperature thermal processes, which volatilize metals and form metallic oxide particulates, include the fluidized bed reactor, the rotary kiln, and the multihearth kiln. Potentially applicable high-temperature thermal treatment

processes include high-temperature vitrification, which melts and volatilizes all components of the contaminated medium. Volatile contaminants and gaseous oxides of sulfur are driven off as gases in the process, and the nonvolatile, molten material that contains contaminants is cooled and, in the process, vitrified.

Thermal treatment technologies can be applied to a wet or dry contaminated medium; however, the effectiveness may vary somewhat with variable moisture content and particle size. Crushing may be necessary as a pretreatment step, especially for large and variable particle sizes, such as the materials in waste rock dumps. Moderate-temperature thermal processes should be considered only as pretreatment for other treatment options. This process concentrates the contaminants into a highly mobile (and potentially more toxic) form. High-temperature thermal processes immobilize most metal contaminants into a vitrified slag that would require proper disposal. The volatile metals would be removed or concentrated into particulate metal oxides, which would likely require disposal as hazardous waste. Thermal treatment costs are extremely high compared with other potentially applicable reclamation technologies.

Excavation and subsequent thermal treatment are not considered feasible options because the large volume of waste makes treatment cost prohibitive. Other feasible options can provide equal protectiveness.

#### **6.4.1.5 In-Place Treatment**

In-place treatment involves treating the contaminated medium where it is currently located. In-place technologies reduce the mobility and toxicity of the contaminated medium and may reduce worker exposure to the contaminated materials; however, they allow a lesser degree of control, in general, than do ex situ treatment options.

#### **Physical and Chemical Treatment**

Potentially applicable in-place physical and chemical treatment technologies include stabilization and solidification, soil flushing, and dewatering.

In-place stabilization and solidification are similar to conventional stabilization in that a solidifying agent (or combination of agents) is used to create a chemical or physical change in the mobility and toxicity of

the contaminants. The in-place process uses deep-mixing techniques to allow maximum contact of the solidifying agents with the contaminated medium.

Soil flushing is an innovative process that injects an acidic or basic reagent or chelating agent into the contaminated medium to solubilize metals. The solubilized metals are extracted using established dewatering techniques, and the extracted solution is then treated to recover metals or is disposed of as aqueous waste. Low-permeability materials may hinder proper circulation, flushing solution reaction, and ultimate recovery of the solution. Currently, soil flushing has been demonstrated only at the pilot scale.

Dewatering is a common pretreatment process used to extract water from a contaminated solid medium. Common dewatering options include well-field extraction, extraction trenches, surface water diversion, and gravity draining of stockpiled saturated materials. Dewatering is most effective in conjunction with additional reclamation technologies that reduce contaminant toxicity, mobility, or volume.

In-place physical and chemical treatment is not considered a feasible option because the large volume of waste and remoteness of the site make the treatment cost prohibitive. Other feasible options can provide equal or greater protectiveness.

### **Thermal Treatment**

In-place vitrification is an innovative process used to melt contaminated solid media in place to immobilize metals into a glass-like, inert, nonleachable solid matrix. Vitrification requires significant energy to generate sufficient current to force the solid medium to act as a continuous electrical conductor. This technology is seriously inhibited by high moisture content. Furthermore, gases generated by the process must be collected and treated in an off-gas treatment system. In-place vitrification has been demonstrated only at the pilot scale, and treatment costs are extremely high compared with other treatment technologies.

In-place thermal treatment is not considered a feasible option because the large volume of waste and remoteness of the site make the treatment cost prohibitive. Other feasible options can provide equal or greater protectiveness.

#### **6.4.2 Screening Summary and Identification of Reclamation Alternatives**

A summary of the initial screening of reclamation response actions, technologies, and process options is provided in Table 6-4. The next step in the evaluation and selection process for a reclamation alternative is alternative screening. The alternative screening compares the options identified based on the NCP criteria of effectiveness, implementability, and relative costs, and eliminates alternatives to reduce the number carried forward for detailed analysis. Alternatives can be eliminated from further consideration if they do not meet the criteria of effectiveness or implementability. In addition, an alternative can be eliminated if its cost is substantially higher than other alternatives and at least one other alternative is retained that offers equal protectiveness. This second level of alternative screening is effective as a method of reducing the number of options that will require a subsequent detailed analysis.

The reclamation response actions, technologies, and process options that were retained have been combined into the reclamation alternatives shown in Table 6-5. Five feasible reclamation alternatives were identified. All of these alternatives will be carried through to the detailed analysis because this number of alternatives is not unreasonably high, and since none of these alternatives could obviously be eliminated through an additional screening step.

**TABLE 6-4**

**RECLAMATION TECHNOLOGY SCREENING COMMENTS SUMMARY - SOLID MEDIA  
BIG CHIEF-GOLCONDA MINE SITE**

General Response Actions	Reclamation Technology	Process Options	Description	Screening Comment
NO ACTION	None	Not applicable	No action	Not applicable
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing/Barrier	Install fences around waste areas to limit access	Potentially effective in conjunction with other technologies; readily implementable
ENGINEERING CONTROLS	Surface Controls	Consolidation, Grading, Revegetation, Erosion Protection	Combine similar waste types in a common area; level out waste piles to reduce slopes for managing surface water infiltration, runoff, and erosion; add amendments to waste and seed with appropriate vegetative species to establish an erosion-resistant ground surface	Effectiveness is questionable since waste contains high concentrations of phytotoxic chemicals; limits direct exposure; readily implementable
	Containment	Earthen Cover	Apply soil and establish vegetative cover to stabilize surface; waste materials are left in place	Surface infiltration and runoff potential would be reduced, but not prevented; limits direct exposure; readily implementable
		Earthen and Geomembrane Cap	Install geomembrane with soil and vegetation over surface; waste materials are left in place	Surface infiltration and runoff potential would be significantly reduced, or eliminated; limits direct exposure; readily implementable
	On-Site Disposal	Earthen Cover	Excavate waste materials and deposit on site in a constructed repository with an earthen cover	Surface infiltration and runoff potential would be reduced, but not prevented; limits direct exposure; readily implementable
		Earthen and Geomembrane Cap	Excavate waste materials and deposit on site in a constructed repository with an earthen and geomembrane cap	Surface infiltration and runoff potential would be significantly reduced, or eliminated; limits direct exposure; readily implementable
		Modified RCRA Subtitle C Repository	Excavate waste materials and deposit on site in a constructed modified RCRA Subtitle C Repository	Surface infiltration and runoff potential would be significantly reduced, or eliminated; limits direct exposure; readily implementable
		RCRA Subtitle C Repository	Excavate waste materials and deposit on site in a constructed RCRA Subtitle C Repository	Potentially effective for all Bevill-exempt wastes; more costly and potentially more effective than Modified RCRA repository, but added protection not considered necessary at this site

**TABLE 6-4 (Continued)**

**RECLAMATION TECHNOLOGY SCREENING COMMENTS SUMMARY - SOLID MEDIA  
BIG CHIEF MINE SITE**

General Response Actions	Reclamation Technology	Process Options	Description	Screening Comment
ENGINEERING CONTROLS (Continued)	Off-Site Disposal	Modified RCRA Subtitle C Repository	Excavate waste materials and deposit on site in a constructed modified RCRA Subtitle C Repository	Surface infiltration and runoff potential would be effectively eliminated; limits direct exposure; readily implementable if site is available for construction of repository
		Solid Waste Landfill	Excavate and dispose of nonhazardous solid wastes permanently in a non-RCRA facility	Potentially effective for nonhazardous materials or nonhazardous residues from other treatment process options; readily implementable, but cost prohibitive
		RCRA Subtitle C Landfill	Excavate and dispose of wastes permanently in a RCRA-permitted facility	Potentially effective and readily implementable; but cost prohibitive
EXCAVATION AND TREATMENT	Fixation/Stabilization	Cement/Silicates	Incorporate hazardous constituents into non-leachable cement or pozzolan solidifying agents	Extensive treatability testing required; proper disposal of stabilized product would be required; potentially implementable, but cost-prohibitive
	Reprocessing	Milling/Smelter	Ship wastes to existing milling/smelter facility for economic extraction of metals	Potentially effective, but a facility is not located in the area
	Physical/Chemical Treatment	Soil Washing	Separate hazardous constituents from solid media via dissolution and subsequent precipitation	Effectiveness is questionable; potential exists to increase mobility by providing partial dissolution of contaminants; more difficulty encountered with wider range of contaminants
		Acid Extraction	Mobilize hazardous constituents via acid leaching and recover by subsequent precipitation	Effectiveness is questionable; sulfides would be acid soluble only under extreme conditions of temperature and pressure
		Alkaline Leaching	Use alkaline solution to leach contaminants from solid media in a heap, vat, or agitated vessel	Effectiveness is not well documented for arsenic
	Thermal Treatment	Fluidized Bed Reactor/Rotary Kiln/Multihearth Kiln	Concentrate hazardous constituents into a small volume by volatilization of metals and formation of metallic oxides as particulates	Further treatment is required to treat process by-products; potentially implementable, but cost prohibitive
		Vitrification	Use extremely high temperature to melt and/or volatilize all components of the solid media; the molten material is cooled and, in the process, vitrified into a nonleachable form	Further treatment is required to treat process by-products; potentially implementable, but cost prohibitive

**TABLE 6-4 (Continued)**

**RECLAMATION TECHNOLOGY SCREENING COMMENTS SUMMARY - SOLID MEDIA  
BIG CHIEF MINE SITE**

General Response Actions	Reclamation Technology	Process Options	Description	Screening Comment
IN-PLACE TREATMENT	Physical/ Chemical Treatment	Stabilization	Stabilize waste constituents in place when combined with injected stabilizing agents	Extensive treatability testing required; potentially implementable, but cost prohibitive
		Solidification	Use solidifying agents in conjunction with deep soil mixing techniques to facilitate a physical or chemical change in mobility of the contaminants	Extensive treatability testing required; potentially implementable, but cost prohibitive
		Soil Flushing	Acid/base reagent or chelating agent injected into solid media to solubilize metals; solubilized reagents are subsequently extracted using dewatering techniques	Effectiveness not certain; innovative process currently in its pilot stage
	Thermal Treatment	Vitrification	Subject contaminated solid media to extremely high temperature in place; during cooling, material is vitrified into non-leachable form	Difficulties may be encountered in establishing adequate control; potentially implementable, but cost prohibitive

Note: Eliminated alternatives are shaded.

RCRA: Resource Conservation and Recovery Act

**TABLE 6-5**

**RECLAMATION ALTERNATIVE INITIAL SCREENING SUMMARY - SOLID MEDIA  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Waste Type</b>	<b>Alternative Number</b>	<b>Alternative Description</b>
Site-Wide Waste Waste Rock and Sediment	Alternative 1	No Action
	Alternative 2	Excavation and On-Site Disposal in Repository (with earthen cap or earthen and geomembrane cap)
	Alternative 3	Excavation and Off-Site Disposal at the Washington Mine Repository
	Alternative 4	Excavation and Off-Site Disposal in Leach Pad #1 Repository

**6.5 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES**

The third step in the selection process for reclamation alternatives for the Big Chief-Golconda Mine Site is the detailed analysis. The detailed analysis evaluates the screened reclamation alternatives for their effectiveness, implementability, and cost to control and reduce the toxicity, mobility, and volume of mine wastes at the Big Chief-Golconda Mine Site.

As required by CERCLA and the NCP, reclamation alternatives that were retained after the initial and alternative screening selection processes were evaluated individually against the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Acceptance by the supporting agencies and community are additional criteria that will be addressed after MWCB and the public review the alternative evaluations presented. These analysis criteria have been used to address the CERCLA requirements and considerations with EPA guidance (1988), as well as additional technical and policy considerations. The criteria also serve as the basis for conducting the detailed analysis and subsequently selecting the preferred reclamation alternative.

The criteria listed above are categorized into three groups, each with distinct functions in selecting the preferred alternative. These groups include:

- **Threshold Criteria** — overall protection of human health and the environment and compliance with ARARs.
- **Primary Balancing Criteria** — long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; short-term effectiveness, implementability, and cost.
- **Modifying Criteria** — state and community acceptance.

Overall protection of human health and the environment and compliance with ARARs are threshold criteria that must be satisfied for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost are the primary balancing criteria used to weigh major trade-offs among alternative hazardous waste management strategies. State and community acceptance are modifying criteria that are formally considered after public comment is received on the proposed reclamation approach and the EEE/CA report. Each criterion is presented and described further in Table 6-6.

The final step of this analysis is a comparative analysis of the alternatives. The analysis will discuss each alternative's relative strengths and weaknesses with respect to each of the criteria, and how reasonably key uncertainties could change expectations of the relative performance. Once completed, this evaluation will be used to select the preferred alternatives. The selection will be documented in a decision document. Public meetings to present the alternatives will be conducted, and significant oral and written comments will be addressed in writing.

The reclamation alternatives that were retained after the initial and alternative screening selection processes are included in the detailed analysis. Each reclamation alternative considered for use at the Big Chief-Golconda Mine Site is classified as an interim or removal action and is not considered a complete reclamation action. In addition, the reclamation alternatives apply to the solid media only; no reclamation alternatives were developed for treatment of groundwater, surface water, or off-site stream sediments. Alternatives were not developed for these media because the analysis assumed that remediating the solid media will subsequently reduce or eliminate the potential impacts to groundwater, surface water, and off-site stream sediments.

**TABLE 6-6**

**ANALYSIS OF SCREENED RECLAMATION ACTIVITIES - SOLID MEDIA  
BIG CHIEF-GOLCONDA MINE SITE**

THRESHOLD CRITERIA				
Overall Protection of Human Health and the Environment		Compliance with ARARs		
<ul style="list-style-type: none"><li>How alternative provides human health and environmental protection</li></ul>		<ul style="list-style-type: none"><li>Compliance with chemical-specific ARARs</li><li>Compliance with action-specific ARARs</li><li>Compliance with location-specific ARARs</li><li>Compliance with other criteria, advisories, and guidance (TBCs)</li></ul>		
PRIMARY BALANCING CRITERIA				
Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost
<ul style="list-style-type: none"><li>Magnitude of residual risk</li><li>Adequacy and reliability of controls</li></ul>	<ul style="list-style-type: none"><li>Treatment process used and materials treated</li><li>Amount of hazardous materials destroyed or treated</li><li>Degree of expected reductions in toxicity, mobility, and volume</li><li>Degree to which treatment is irreversible</li><li>Type and quantity of residuals remaining after treatment</li></ul>	<ul style="list-style-type: none"><li>Protection of community during removal actions</li><li>Protection of workers during removal actions</li><li>Environmental impacts</li><li>Time until removal action objectives are achieved</li></ul>	<ul style="list-style-type: none"><li>Ability to construct and operate the technology</li><li>Reliability of the treatment</li><li>Ease of undertaking additional removal actions, if necessary</li><li>Ability to obtain approvals from other agencies</li><li>Coordination with other agencies</li><li>Availability of off-site treatment, storage, and disposal services and capability</li><li>Availability of necessary equipment and specialists</li><li>Availability of prospective technologies</li></ul>	<ul style="list-style-type: none"><li>Capital costs</li><li>Operating and maintenance costs</li><li>Present worth cost</li></ul>

**TABLE 6-6 (Continued)**

**ANALYSIS OF SCREENED RECLAMATION ACTIVITIES - SOLID MEDIA  
BIG CHIEF-GOLCONDA MINE SITE**

MODIFYING CRITERIA	
Supporting Agency Acceptance <sup>a</sup>	Community Acceptance <sup>a</sup>
<ul style="list-style-type: none"><li>• Features of the alternative the supporting agencies support</li><li>• Features of the alternative about which the supporting agencies have reservations</li><li>• Elements of the alternative the supporting agencies strongly oppose</li></ul>	<ul style="list-style-type: none"><li>• Features of the alternative the community supports</li><li>• Features of the alternative about which the community has reservations</li><li>• Elements of the alternative the community strongly opposes</li></ul>

Note:

<sup>a</sup> These criteria are being assessed primarily based on public comment on the RI report (TiEMI 2005) and the expanded engineering evaluation/cost analysis.

### 6.5.1 Evaluation of Threshold Criteria

Each reclamation alternative was assessed for overall risk reduction and evaluated for compliance with ARARs in the following detailed evaluations of the threshold criteria. The exposure pathways of concern (ingestion, inhalation, and dermal) that were identified in the risk assessment were qualitatively and quantitatively evaluated to identify the risk reduction required to achieve the desired residual risk level (HQ less than 1 or risk less than  $1.0 \times 10^{-6}$ ) to assess the threshold criteria (overall protection of human health and the environment, and attainment of ARARs). Each alternative was evaluated to ascertain the degree of risk reduction achieved, either through reduced contaminant loading to an exposure pathway or reduced surface area available for certain exposures. The resulting risk reduction estimates were then compared with one another to evaluate whether the relative risk reduction provided by a specific alternative is greater than another; these risk reductions were also compared with the reduction required to alleviate excess risk via the specific pathway or media. The risk reduction models also estimated resultant contaminant concentrations in the various media, which were then compared with medium- and contaminant-specific ARARs.

Modeling estimates and assumptions were used in an attempt to quantify risk reduction and evaluate whether ARARs would be attained. Several assumptions and estimates were used in this analysis. Some of the assumptions were based on standard CERCLA risk assessment guidance, while others were based on site-specific observation and professional judgment. Many of the estimates were based on conservative or worst case scenarios, but since alternatives were compared with one another, these assumptions were consistent. The evaluation findings should, therefore, not be considered absolute; however, the relative risk reduction differences between alternatives are meaningful and can be used to evaluate this criterion.

The human health risk assessment considered that the most probable and representative exposure pathway at the Big Chief-Golconda Mine Site was a recreational receptor (maximum use of 50 days per year) under the rockhound/goldpanner (RH/GP) exposure scenario. Even though a cabin is located adjacent to the site, the cabin is not occupied year-round. The screening level risk assessments completed for the Big Chief-Golconda Mine Site identified arsenic, lead, and manganese as the contaminants of concern for human exposure. Only lead was detected in soil at concentrations above the recreational cleanup guideline.

Reduction in risk to human health posed by the wastes found at the Big Chief-Golconda Mine Site is best addressed by reducing the area of exposed wastes, either by covering or removing contaminated wastes. The evaluation of methods to reduce the exposed contaminated surface area must also consider the long-term stability and eventual partial failure of cover or containment systems.

The ecological risk assessment identified three exposure scenarios as determined by EQs greater than 1: (1) plant phytotoxicity to arsenic, cadmium, copper, and zinc; (2) deer ingestion of lead; and (3) surface water aquatic life for zinc and sediment aquatic life for zinc. The aquatic life scenario would require reduction in metals loading to surface water and reduction in levels of metals in sediment to achieve acceptable risks. The deer ingestion scenario would likely require a reduction in lead levels in surface soil to achieve no potential risks to deer. The plant phytotoxicity scenario also requires a reduction in surface concentrations or exposed surface area of arsenic, cadmium, copper, and zinc to achieve no phytotoxic effects (EQ less than or equal to 1). Phytotoxic effects will be reduced through exposure reduction associated with the human health risk exposure evaluations.

The maximum exposure concentrations detected during the preliminary site inspection (DEQ/MWCB 2004) and reclamation investigation for the entire reclamation area are: arsenic 153 mg/kg, cadmium 68 mg/kg, copper 883 mg/kg, lead 32,300 mg/kg, manganese 4,630 mg/kg, and zinc 12,300 mg/kg. The amount of contaminant reduction required to meet cleanup guidelines for recreational exposure is 85 percent for lead. The concentrations must be reduced for arsenic by 33 percent; cadmium by 88 percent; copper by 86 percent; and zinc by 97 percent for plant phytotoxicity. The lead concentration must be reduced by 99 percent for ingestion by deer. The surface water loading concentration for zinc must be reduced by 7 percent.

#### **6.5.2 Alternative 1: No-Action**

Under this alternative, no reclamation activities would be implemented. Consequently, long-term human health and environmental risks associated with the on-site contamination are assumed to remain unchanged. The no-action alternative is used to provide a baseline for comparing other alternatives and is included as required under CERCLA and the NCP.

#### **6.5.2.1 Overall Protection of Human Health and the Environment**

The no-action alternative provides no control of exposure to the contaminated materials and no reduction in risk to human health or the environment. Under this alternative, site contaminants would continue to migrate to air, groundwater, surface water, and stream sediment.

Protection of human health would not be achieved under the no-action alternative. Prevention of direct human exposure through the pathways of concern would not be achieved. Ingestion, dermal contact, and inhalation of soil containing metals would not be reduced. Protection of the environment would also not be achieved under the no-action alternative. Risks posed by ecological exposures through all scenarios would remain unchanged.

#### **6.5.2.2 Compliance with ARARs**

A comprehensive list of federal and state ARARs is summarized in Section 6.0 and is presented in detail in Appendices F and G. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Under the no-action alternative, no contaminated materials would be treated, removed, or actively managed. However, leaching and releases of contaminants to groundwater and surface water would not be reduced under this alternative and surface water standards would continue to be exceeded.

#### **6.5.2.3 Long-Term Effectiveness and Permanence**

Under the no-action alternative, no controls or long-term measures would be imposed on the contaminated materials at the site; consequently, this alternative provides no long-term effectiveness. Therefore, the no-action alternative would not be effective at minimizing risks from exposure to site wastes.

#### **6.5.2.4 Reduction of Toxicity, Mobility or Volume through Treatment**

The no-action alternative would not reduce the toxicity, mobility, or volume of the contaminated materials.

#### **6.5.2.5 Short-Term Effectiveness**

The no-action alternative would not create any short-term risks.

#### **6.5.2.6 Implementability**

The no-action alternative is readily implementable.

#### **6.5.2.7 Costs**

No costs are associated with the no-action alternative.

### **6.5.3 Alternative 2: Excavation and On-Site Disposal in Repository (with earthen cap [Alternative 2a] or Geomembrane Liner and Earthen Cap [Alternative 2b])**

Under this alternative, mine waste at the site would be excavated and disposed of in an on-site repository. The steps include the following: (1) excavating and preparing the repository subgrade; (2) installing a geocomposite bottom liner and leachate collection system (Alternative 2b); (3) excavating and consolidating the waste materials in the repository; (4) capping the waste with an 18-inch thick earthen cap (Alternative 2a) or a geocomposite liner and an 18-inch thick earthen cap (Alternative 2b); and (5) revegetating the repository cap and the disturbed areas.

Repository preparation would involve placement of subgrade cushion and installation of a geocomposite bottom liner and leachate collection system. Some of the clean soils excavated from within the footprint of the repository may be stockpiled for later use in the repository cap. General mine wastes would then be excavated and placed into the repository. As the waste rock is placed in the repository, the waste would be graded and compacted. Eighteen inches of soil cover (Alternative 2a) or a geocomposite liner and 18 inches of soil cover (Alternative 2b) would be placed over the waste.

After the soil cover is placed over the waste, the repository slopes would be graded to 3 to 1 slopes or less to minimize potential for surface erosion. Next, the disturbed areas would be prepared for revegetation, including the removal areas and the repository cap. The excavated areas would be graded to match the contour of the land surface and, if necessary, cover soil would be applied to the disturbed areas.

Revegetation would likely take place during the fall of the year. The seed mixture and fertilizer would be simultaneously drilled into the prepared seed beds. Mulch would be applied to promote temporary protection of the disturbed erodible surfaces.

Heavy equipment would be required on site to implement this alternative efficiently. Multiple large-capacity haul trucks, bulldozers, front-end loaders, excavators, and compactors would be needed to construct the repository and excavate and haul the material.

#### **6.5.3.1 Overall Protection of Human Health and the Environment**

This alternative would provide a means of reducing or eliminating the threat of direct contact with the waste material as well as reducing the risk of airborne exposure and soil ingestion. In addition, isolating the waste would provide environmental protection by limiting the infiltration of precipitation and surface water that may leach contaminants to the groundwater.

The threat of direct human exposure would essentially be eliminated by this alternative. The potential for ingestion, dermal contact, and inhalation of soil that contains lead would be eliminated over the long term. Risks would be reduced to acceptable levels for recreational land uses.

Protection of the environment would be achieved under this alternative. Ecological exposures through all scenarios, including exposure of deer to lead through ingestion of surface salts, and phytotoxic concentrations of metals would also be reduced to acceptable levels or possibly eliminated.

#### **6.5.3.2 Compliance with ARARS**

There are no federal or state contaminant-specific ARARs that are required to be met for containing contaminated mine waste at the Big Chief-Golconda Mine Site. However, removal and disposal of the specified waste in a constructed repository are expected to satisfy federal and state surface water and groundwater standards, including MCLs and HHS. The contaminants would not be expected to leach to surface water or groundwater because the primary waste sources of concern would be physically isolated from groundwater using a liner and cap system.

Implementation of this alternative is expected to satisfy air quality regulations because encapsulating the waste would stabilize the materials with respect to fugitive emissions.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring safety training for all on-site workers during the construction phase of the project.

Location-specific ARARs are expected to be met without any conflicts. Contacts with appropriate agencies regarding wetlands, floodplains, and paleontological resources would be required.

All action-specific ARARs are anticipated to be met, including the hydrological regulations promulgated under the Strip and Underground Mine Reclamation Act. The mining wastes were derived from the beneficiation and extraction of ores and are, therefore, assumed to be exempt from federal government regulation through RCRA as hazardous waste. In addition, revegetation requirements promulgated under the Surface Mining Control and Reclamation Act would be met. State of Montana dust suppression and control requirements are applicable for earth-moving activities associated with this alternative for control of fugitive dust emissions; these requirements would be met by applying water to roads that receive heavy vehicular traffic and to excavation areas, if necessary.

#### **6.5.3.3 Long-Term Effectiveness and Permanence**

The long-term effectiveness and permanence of the repository depend on proper maintenance, including long-term monitoring and routine inspections, to ensure that the system performs as designed. The repository cap would be the component most vulnerable to any damage or degradation. Single or multilayered caps are susceptible to erosion, settlement, and disruption of the cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. Multilayer caps are also susceptible to ponding of surface water. The actual design life of the repository is not certain; however, the required maintenance could be identified and implemented since the repository would be periodically inspected. In addition, institutional controls would be required to prevent land uses that are incompatible with the reclaimed site. Specifically, land uses that would compromise the repository cap should be precluded.

In addition, revegetation of the excavated areas and the repository cap would stabilize the land surface by providing protection from erosion by surface water and wind and would reduce net infiltration through the media by increasing the evapotranspiration process. Determining the proper grading layout for the area, selecting good quality soil cover, and selecting the appropriate plant species for revegetation would enhance the long-term effectiveness of this alternative. Long-term effectiveness would likely be improved by selecting metal-tolerant plant species adapted to short growing seasons.

#### **6.5.3.4 Reduction of Toxicity, Mobility or Volume through Treatment**

The objective of this alternative is to reduce contaminant mobility, although the waste is not treated. The volume or toxicity of the contaminants would not be physically reduced. Containing the mine waste in a repository would stabilize the source area and reduce and possibly eliminate contaminant mobility from surface water and wind erosion through the use of impermeable liners that encapsulate the mine waste. The mobility of the contaminants would be reduced to an extent that would result in an overall risk reduction from all pathways and routes of exposure.

#### **6.5.3.5 Short-Term Effectiveness**

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. These potential short-term impacts would be mitigated during the construction phase. On-site workers would be adequately protected by using personal protective equipment and by following proper operating and safety procedures. However, short-term air quality impacts to the surrounding environment may occur during waste consolidation and grading. Fugitive dust emissions would be controlled by applying water to surfaces that receive heavy vehicular traffic or in excavation areas, as needed. Short-term impacts to people residing or recreating in the vicinity of the site are expected to be minimal. A measurable short-term impact to the surrounding area would include increased vehicular traffic, associated safety hazards, and potential dust generation in association with construction in the vicinity of Jefferson City, Montana.

#### **6.5.3.6 Implementability**

This alternative is technically and administratively feasible and could be implemented within one field season. The construction of a repository with a single layer or multilayered cap is considered a conventional construction practice; materials and construction methods are readily available. Constructing the repository may require the services of a contractor experienced in the proper installation procedures. In addition, design methods and requirements are well documented and understood.

Components or factors that could prolong implementation of this alternative as planned include: (1) locating an adequate source of earthen cover material and cover soil (or suitable plant-growth media); (2) controlling fugitive dust emissions and storm water discharge during reclamation; and (3) addressing

landowner concerns. However, these concerns also apply to other reclamation alternatives considered for the site.

### **6.5.3.7 Costs**

The total present worth cost for Alternative 2a, excavation and on-site disposal in an earthen capped repository, has been estimated at \$170,301. Table 6-7 presents the itemized capital and operations and maintenance costs associated with implementing this alternative. The total present worth cost for Alternative 2b, excavation and on-site disposal in an earthen and geomembrane capped repository, has been estimated at \$212,212. Table 6-8 presents the itemized capital and operations and maintenance costs associated with implementing this alternative.

### **Conceptual Design Assumptions**

The following assumptions were used to develop costs directly and to calculate associated costs for this alternative:

- One repository with a total surface area of approximately 0.4 acres would be prepared on site.
- An estimated 5,000 cy of waste rock and tailings would be excavated and consolidated in the repository using excavators, scrapers, and dozers.
- The top 2 feet of consolidated and graded waste would be amended with lime for the earthen cover option (Alternative 2a). Waste materials would require lime amending at an average of 270 tons of lime per acre from acid-base accounting results. Lime would be incorporated into the top 2 feet of material using a dozer ripper or plow. The 0.4 acre footprint of waste would require approximately 108 tons of lime. No lime would be required for the earthen cap with geomembrane liner option (Alternative 2b).
- An earthen cap (Alternative 2a), or an earthen and geocomposite liner and cap consisting of a geosynthetic clay liner and a geocomposite drainage fabric (Alternative 2b) would be used to construct the repository. The geocomposite cap would be covered with 12 inches of common borrow and 6 inches of cover soil totaling 980 cy. An estimated 3,900 square yards of geocomposite liner would be needed to construct the repository for Alternative 2b. Approximately 1,250 cy of screened material will be required to cushion the geosynthetic liner and cap.
- It is assumed that all of waste excavation areas (2 acres) would require some addition of cover soil to establish suitable vegetation. The excavation areas would be covered with 6 inches of cover soil totaling 1,620 cy. It is assumed that a coversoil source is located within a 1-mile radius of the site and would not require permitting.

Insert Table 6-7

Insert Table 6-8

- A total of 2.5 acres of disturbed ground, including the repository, excavated area, soil borrow area, and staging area, would require revegetation.
- Reconstruct 500 linear feet of surface water drainage (Golconda Creek). Filter fabric and riprap would be placed to minimize erosion and ensure bank stability.
- A four-strand barbed-wire fence would surround any revegetated areas to promote plant growth and minimize erosion caused by potential vehicular traffic. The total length of fence required to surround the area is estimated to be 1,500 linear feet.
- A woven wire fence would be placed around the repository. The total length of fence required would be about 560 linear feet.
- Access roads to and through the site (0.5 miles) would need improvement, and a temporary bridge would be constructed to allow unobstructed access for heavy equipment.

#### **6.5.4 Alternative 3: Excavation and Off-Site Disposal at the Washington Mine Site Repository**

Under this alternative, mine wastes materials at the site would be excavated and disposed of in the Washington Mine site repository, 10 miles west of the site. The steps include the following: (1) improving the road to the Big Chief-Golconda Mine and Washington Mine site repository; and (2) excavating, hauling, and consolidating the waste materials in the repository. Other reclamation measures that relate to construction of the Washington Mine site repository, including revegetating the repository site, would be implemented under actions conducted as part of reclamation of the Washington Mine site.

The disturbed areas would be prepared for revegetation, including the removal and soil borrow areas. The excavated areas would be graded to match the contour of the land surface and, if necessary, cover soil would be applied to the disturbed areas. Open adits would be backfilled and closed.

Revegetation would likely take place during the fall of the year. The seed mixture and fertilizer would be simultaneously drilled into the prepared seed beds. Mulch would be applied to promote temporary protection of the disturbed erodible surfaces.

Heavy equipment would be required on site to implement this alternative efficiently. Multiple large-capacity haul trucks, bulldozers, front-end loaders, excavators, and compactors would be needed to excavate and haul the material.

#### **6.5.4.1 Overall Protection of Human Health and the Environment**

This alternative would provide a means of reducing or eliminating the threat of direct contact with the waste material as well as reducing the risk of airborne exposure and soil ingestion. In addition, isolating the waste would provide environmental protection by limiting infiltration of precipitation and surface water that may leach contaminants to groundwater.

The threat of direct human exposure would essentially be eliminated by this alternative. The potential for ingestion, dermal contact, and inhalation of soil that contains lead would be eliminated over the long term. Risks would be reduced to acceptable levels for recreational land uses.

Protection of the environment would be achieved under this alternative. Ecological exposures through all scenarios, including exposure of deer to lead through ingestion of surface salts, and plant phytotoxicity would also be reduced to acceptable levels or possibly eliminated.

#### **6.5.4.2 Compliance with ARARS**

No federal or state contaminant-specific ARARs are required to be met for containing contaminated mine waste in a waste repository. However, removal of the specified waste and disposal in a constructed repository are expected to satisfy federal and state surface water and groundwater standards, including MCLs and HHS. The contaminants would not be expected to leach to surface water or groundwater because the primary waste sources of concern would be physically isolated from groundwater using a liner system and a liner cap.

Implementation of this alternative is expected to satisfy air quality regulations because encapsulating the waste would stabilize the materials with respect to fugitive emissions.

OSHA requirements would be met by requiring safety training for all on-site workers during the construction phase of the project.

Location-specific ARARs are expected to be met without any conflicts. Contacts with appropriate agencies regarding wetlands, floodplains, and paleontological resources would be required.

All action-specific ARARs are anticipated to be met, including the hydrological regulations promulgated under the Strip and Underground Mine Reclamation Act. The mining wastes were derived from the beneficiation and extraction of ores and are, therefore, assumed to be exempt from federal government regulation through RCRA as hazardous waste. In addition, revegetation requirements promulgated under the Surface Mining Control and Reclamation Act would be met. State of Montana dust suppression and control requirements apply to earth-moving activities associated with this alternative to control fugitive dust emissions; these requirements would be met by applying water to roads that would receive heavy vehicular traffic and to excavation areas, if necessary.

#### **6.5.4.3 Long-Term Effectiveness and Permanence**

The long-term effectiveness and permanence of the repository depend on proper maintenance, including long-term monitoring and routine inspections, to ensure that the system performs as designed. The repository cap would be the component most vulnerable to any damage or degradation. Multilayered caps are susceptible to ponding of surface water, erosion, settlement, and disruption of the cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. The actual design life of the repository is not certain; however, the required maintenance could be identified and implemented since the repository would be periodically inspected. In addition, institutional controls would be required to prevent land uses that would be incompatible with the reclaimed site. Specifically, land uses that would compromise the repository cap should be precluded.

In addition, revegetation of the excavated areas and the repository cap would stabilize the land surface by providing protection from erosion by surface water and wind and would reduce net infiltration through the media by increasing the evapotranspiration process. Determining the proper grading layout for the area, selecting good quality soil cover, and selecting the appropriate plant species for revegetation would enhance the long-term effectiveness of this alternative. Long-term effectiveness would likely be improved by selecting metal-tolerant plant species adapted to short growing seasons.

#### **6.5.4.4 Reduction of Toxicity, Mobility or Volume through Treatment**

The objective of this alternative is to reduce in contaminant mobility, although the waste is not treated. The volume or toxicity of the contaminants would not be physically reduced. Containing the mine waste in an off-site repository would eliminate the solid media from the source area and reduce contaminant mobility through surface water and wind erosion. The contaminated material in the off-site repository

would be stabilized through the use of impermeable liners that encapsulate the mine waste. The mobility of the contaminants would be reduced to an extent that would result in an overall risk reduction from all pathways and routes of exposure.

#### **6.5.4.5 Short-Term Effectiveness**

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. These potential short-term impacts would be mitigated during the construction phase. On-site workers would be adequately protected by using personal protective equipment and by following proper operating and safety procedures. However, short-term air quality impacts to the surrounding environment may occur during waste excavation, hauling, and consolidation. Fugitive dust emissions would be controlled by applying water to surfaces that would receive heavy vehicular traffic or in excavation areas, as needed. Short-term impacts to people who reside or recreate in the vicinity of the site are expected to be minimal. A measurable short-term impact to the surrounding area would include increased vehicular traffic in the towns of Jefferson City and Wickes, Montana, associated safety hazards, and potential dust generation at the Big Chief-Golconda Mine and Washington Mine site repository in association with construction.

#### **6.5.4.6 Implementability**

This alternative is technically feasible and could be implemented within one field season. The excavation of mine waste and disposal in a repository is considered a conventional construction practice; materials and construction methods are readily available. Disposal in the regional repository may require the services of a contractor experienced in the proper installation procedures. In addition, design methods and requirements are well documented and understood.

Components or factors that could prolong implementation of this alternative as planned include: (1) locating an adequate source of earthen cover material and cover soil (or suitable plant-growth media), (2) controlling fugitive dust emissions and storm water discharge during reclamation, and (3) improving the road between the Big Chief-Golconda Mine and Washington Mine site repository. However, these concerns are applicable to other reclamation alternatives considered for the site.

#### **6.5.4.7 Costs**

The total present worth cost for Alternative 3, excavation and off-site disposal in the Washington Mine site repository, has been estimated at \$214,011. Table 6-9 presents the itemized capital costs and operation and maintenance costs associated with implementing this alternative.

#### **Conceptual Design Assumptions**

The following assumptions were used to develop costs directly and to calculate associated costs for these alternatives:

- An estimated 5,000 cy of waste rock and tailings would be excavated and hauled 10 miles, one way, to the Washington Mine site repository using excavators, loaders, and haul trucks.
- It is assumed that all of the waste excavation areas (2 acres) would require some addition of cover soil to establish suitable vegetation. The excavation areas would be covered with a minimum of 6 inches of cover soil totaling 1,620 cy. It is assumed that a coversoil source is located within a 1-mile radius of the site and would not require permitting.
- A total of 2.5 acres of disturbed ground, including the repository, excavated area, soil borrow area, and staging area, would require revegetation.
- Five hundred linear feet (lf) of surface water drainage (Golconda Creek) would be reconstructed. Filter fabric and riprap would be placed to minimize erosion and ensure bank stability.
- Access roads to and through the site (1.5 miles) would need improvement, and a temporary bridge would be constructed to allow unobstructed access for heavy equipment.
- A four-strand barbed-wire fence would surround any revegetated areas to promote plant growth and minimize erosion due to potential vehicular traffic. The total length of fence required to surround the area is estimated to be 1,500 linear feet.

Costs associated with construction of the Washington Mine site repository, including geocomposite liner material, soil cover and revegetation at the repository site, would be included as part of reclamation of the Washington Mine site.

#### **6.5.5 Alternative 4: Excavation and Off-Site Disposal in Leach Pad #1 Repository at the Basin Creek Mine**

Under this alternative, mine wastes materials at the site would be excavated and disposed of in the Leach Pad #1 repository at Basin Creek Mine, 20 miles west of the site. The steps include the following: (1) improving the road to the Big Chief-Golconda Mine Site, (2) excavating, hauling, and consolidating the waste materials in the repository, and (3) revegetating the repository cap and the disturbed areas.

**Insert Table 6-9**

The disturbed areas would be prepared for revegetation, including the removal and soil borrow areas. The excavated areas would be graded to match the contour of the land surface and, if necessary, cover soil would be applied to the disturbed areas. Open adits would be backfilled and closed.

Revegetation would likely take place during the fall of the year. The seed mixture and fertilizer would be simultaneously drilled into the prepared seed beds. Mulch would be applied to promote temporary protection of the disturbed erodible surfaces.

Heavy equipment would be required on site to implement this alternative efficiently. Multiple large-capacity haul trucks, bulldozers, front-end loaders, excavators, and compactors would be needed to excavate and haul the material.

#### **6.5.5.1 Overall Protection of Human Health and the Environment**

This alternative would provide a means of reducing or eliminating the threat of direct contact with the waste material as well as reducing the risk of airborne exposure and soil ingestion. In addition, isolating the waste would provide environmental protection by limiting infiltration of precipitation and surface water that may leach contaminants to groundwater.

The threat of direct human exposure would essentially be eliminated by this alternative. The potential for ingestion, dermal contact, and inhalation of soil that contains lead would be eliminated over the long term. Risks would be reduced to acceptable levels for recreational land uses.

Protection of the environment would be achieved under this alternative. Ecological exposures through all scenarios, including exposure of deer to lead through ingestion of surface salts, and plant phytotoxicity would also be reduced to acceptable levels or possibly eliminated.

#### **6.5.5.2 Compliance with ARARS**

No federal or state contaminant-specific ARARs are required to be met for containing contaminated mine waste in a waste repository. However, removal of the specified waste and disposal in a constructed repository are expected to satisfy federal and state surface water and groundwater standards, including MCLs and HHS. The contaminants would not be expected to leach to surface water or groundwater

because the primary waste sources of concern would be physically isolated from groundwater using a liner system and a liner cap.

Implementation of this alternative is expected to satisfy air quality regulations because encapsulating the waste would stabilize the materials with respect to fugitive emissions.

OSHA requirements would be met by requiring safety training for all on-site workers during the construction phase of the project.

Location-specific ARARs are expected to be met without any conflicts. Contacts with appropriate agencies regarding wetlands, floodplains, and paleontological resources would be required.

All action-specific ARARs are anticipated to be met, including the hydrological regulations promulgated under the Strip and Underground Mine Reclamation Act. The mining wastes were derived from the beneficiation and extraction of ores and are, therefore, assumed to be exempt from federal government regulation through RCRA as hazardous waste. In addition, revegetation requirements promulgated under the Surface Mining Control and Reclamation Act would be met. State of Montana dust suppression and control requirements are applicable for earth-moving activities associated with this alternative to control fugitive dust emissions; these requirements would be met by applying water to roads that would receive heavy vehicular traffic and to excavation areas, if necessary.

#### **6.5.5.3 Long-Term Effectiveness and Permanence**

The long-term effectiveness and permanence of the repository depend on proper maintenance, including long-term monitoring and routine inspections, to ensure that the system performs as designed. The repository cap would be the component most vulnerable to any damage or degradation. Multilayered caps are susceptible to ponding of surface water, erosion, settlement, and disruption of the cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. The actual design life of the repository is not certain; however, the required maintenance could be identified and implemented since the repository would be periodically inspected. In addition, institutional controls would be required to prevent land uses that would be incompatible with the reclaimed site. Specifically, land uses that would compromise the repository cap should be precluded.

In addition, revegetation of the excavated areas and the repository cap would stabilize the land surface by providing protection from erosion by surface water and wind and would reduce net infiltration through the media by increasing the evapotranspiration process. Determining the proper grading layout for the area, selecting good quality soil cover, and selecting the appropriate plant species for revegetation would enhance the long-term effectiveness of this alternative. Long-term effectiveness would likely be improved by selecting metal-tolerant plant species adapted to short growing seasons.

#### **6.5.5.4 Reduction of Toxicity, Mobility or Volume through Treatment**

The objective of this alternative is to reduce contaminant mobility, although the waste is not treated. The volume or toxicity of the contaminants would not be physically reduced. Containing the mine waste in an off-site repository would eliminate the solid media from the source area and reduce contaminant mobility through surface water and wind erosion. The contaminated material in the off-site repository would be stabilized through the use of impermeable liners that encapsulate the mine waste. The mobility of the contaminants would be reduced to an extent that would result in an overall risk reduction from all pathways and routes of exposure.

#### **6.5.5.5 Short-Term Effectiveness**

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. These potential short-term impacts would be mitigated during the construction phase. On-site workers would be adequately protected by using personal protective equipment and by following proper operating and safety procedures. However, short-term air quality impacts to the surrounding environment may occur during waste excavation, hauling, and consolidation. Fugitive dust emissions would be controlled by applying water to surfaces that would receive heavy vehicular traffic or in excavation areas, as needed. Short-term impacts to people residing or recreating in the vicinity of the Big Chief-Golconda Mine Site are expected to be minimal. A measurable short-term impact to the surrounding area would include increased vehicular traffic in Jefferson City and Helena, Montana, and along the municipal highway haul route, associated safety hazards, and potential dust generation at the Big Chief-Golconda Mine and Leach Pad #1 repository in association with construction.

#### **6.5.5.6 Implementability**

This alternative is technically feasible and could be implemented within one field season. The excavation of mine waste and disposal in a regional repository is considered a conventional construction practice; materials and construction methods are readily available. Disposal in the Leach Pad #1 repository may require the services of a contractor experienced in the proper installation procedures. In addition, design methods and requirements are well documented and understood.

Components or factors that could prolong implementation of this alternative as planned include: (1) locating an adequate source of earthen cover material and cover soil (or suitable plant-growth media); (2) controlling fugitive dust emissions and storm water discharge during reclamation; and (3) improving the road as necessary between the Big Chief-Golconda Mine and Leach Pad #1 repository. However, these concerns apply to other reclamation alternatives considered for the site.

since the repository would be periodically inspected

#### **6.5.5.7 Costs**

The total present worth cost for Alternative 4, excavation and off-site disposal in the Leach Pad #1 repository, has been estimated at \$259,511. Table 6-10 presents the itemized capital and operation and maintenance costs associated with implementing this alternative.

#### **Conceptual Design Assumptions**

The following assumptions were used to develop costs directly and to calculate associated costs for these alternatives:

- An estimated 5,000 cy of waste rock would be excavated and hauled approximately 50 miles, one way, to the Leach Pad #1 repository using excavators, loaders, and haul trucks.
- It is assumed that all of the waste excavation areas (2 acres) would require some addition of cover soil to establish suitable vegetation. The excavation areas would be covered with a minimum of 6 inches of cover soil, totaling 1,620 cy. It is assumed that a source of cover soil is located within a 1-mile radius of the site and would not require permitting.
- A total of 2.5 acres of disturbed ground, including the repository, excavated area, soil borrow area, and staging area, would require revegetation.

**Insert Table 6-10**

- Five hundred linear feet of surface water drainage (Golconda Creek) would be reconstructed. Filter fabric and riprap would be placed to minimize erosion and ensure bank stability.
- A four-strand barbed-wire farm fence would surround any revegetated areas to promote plant growth and minimize erosion caused by potential vehicular traffic. The total length of fence required to surround the area is estimated at 1,500 linear feet.
- Access roads to and through the site (1.5 miles) would need improvement, and a temporary bridge would be constructed to allow unobstructed access for heavy equipment.

## **6.6 COMPARATIVE ANALYSIS OF ALTERNATIVES**

This section compares the reclamation alternatives retained for the Big Chief-Golconda Mine Site. The alternatives retained include: (1) Alternative 1 — No Action; (2) Alternative 2 — Excavation and On-Site Disposal in a Repository; (3) Alternative 3 — Excavation and Off-Site Disposal in the Washington Mine Site Repository; and (4) Alternative 4 — Excavation and Off-Site Disposal in the Leach Pad #1 Repository. The comparison focuses on the two threshold criteria (the relative protectiveness of human health and the environment and the estimated attainment of ARARs) and the primary balancing criteria. The following sections discuss the relative ability of each alternative to meet the threshold criteria.

### **6.6.1 Threshold Criteria**

Alternatives 1, 2, 3, and 4 have all been retained for the Big Chief-Golconda Mine Site. Baseline conditions at the site as represented by Alternative 1, the no action alternative, is not protective of human health and the environment.

Alternative 2 is considered protective of human health and the environment because installation of an earthen cover or an earthen cap with a liner and geocomposite layer would isolate waste rock and tailing wastes from contact with potential receptors and would reduce the potential for inhalation of dust and off-site exposure via erosion. Alternatives 2, 3, and 4 are considered protective of human health and the environment because wastes would be effectively isolated in either on-site or off-site repositories.

Alternatives 2, 3, and 4 would comply with ARARs by isolating the contaminated materials from contact with potential receptors, reducing releases to surface water, and reducing the potential for metals to leach into groundwater. Some surface water standards are exceeded under Alternative 1.

Alternative 1 is the least expensive, at no cost, followed by Alternative 2a (earthen cover) at an estimated cost of \$170,301; Alternative 2b (earthen and geomembrane cap) at an estimated cost of \$212,212; Alternative 3 (off-site disposal at the Washington Mine site repository) at an estimated cost of \$214,011; and Alternative 4 (off-site disposal in the Leach Pad #1 repository) at an estimated cost of \$259,511.

Table 6-11 summarizes the comparative analysis of these four alternatives.

### **6.6.2 Summary**

Alternatives 2, 3, and 4 provide the greatest protection of human health and the environment, compliance with ARARs, long-term effectiveness, reduction in mobility, and short-term effectiveness.

Implementability of Alternative 2 depends on sufficient space being available at the Big Chief-Golconda Mine Site for construction of the proposed repository with a minimum capacity of 5,000 cy.

Implementability of Alternative 3 depends on the concurrent start of reclamation at the Washington Mine site. Implementability of Alternative 4 depends on the availability of the Leach Pad #1 repository site at the Basin Creek mine. Alternative 4, the most expensive option, is about 21 percent more costly than Alternative 3; all of this additional cost is associated with waste hauling to the Leach Pad #1 repository.

Alternative 3 is about the same cost as Alternative 2b but is about 20 percent more expensive than Alternative 2a.

Alternatives 2a, 2b, 3, and 4 provide protection of human health and the environment, compliance with ARARs, short-term effectiveness, and implementability. Alternatives 2b, 3, and 4 are considered to have more long-term effectiveness than Alternative 2a because a geomembrane liner is incorporated into the cap.

### **6.6.3 Preferred Reclamation Alternative**

Alternative 2b will result in slightly less protection of human health and environment than either Alternative 3 or Alternative 4 as wastes would remain on site. Alternatives 3 and 2b have basically the same cost. Alternative 4 will result in slightly more protection of human health and environment than Alternative 3 as the Leach Pad #1 repository is located at a controlled, gated facility. Alternative 3 involves less short-term impact than Alternative 4, as haul routes would not use public highway corridors, or pass through Helena, Montana. Additionally, Alternative 4 is 24 percent more expensive than Alternative 3. For these reasons, Alternative 3 is the preferred reclamation alternative for the Big Chief-

TABLE 6-11

**COMPARATIVE ANALYSIS OF ALTERNATIVES for the  
BIG CHIEF-GOLCONDA MINE SITE**

<b>Assessment Criteria</b>	<b><u>Alternative 1</u> No Action</b>	<b><u>Alternative 2</u> On-Site Repository</b>	<b><u>Alternative 3</u> Off-Site Disposal at the Washington Mine Site Repository</b>	<b><u>Alternative 4</u> Off-Site Disposal in the Leach Pad #1 Repository</b>
<b>Overall Protectiveness</b>				
<i>Public Health, Safety, and Welfare</i>	No reduction in risk.	Exposures expected to be eliminated.	Exposures expected to be eliminated.	Exposures expected to be eliminated.
<i>Environmental Protectiveness</i>	No protection offered.	Exposures expected to be eliminated.	Exposures expected to be eliminated.	Exposures expected to be eliminated.
<b>Compliance with ARARs</b>				
<i>Chemical-Specific</i>	Some surface water standards currently exceeded.	Chemical-specific ARARs would be met.	Chemical-specific ARARs would be met.	Chemical-specific ARARs would be met.
<i>Location-Specific</i>	None apply.	Location-specific ARARs would be met.	Location-specific ARARs would be met.	Location-specific ARARs would be met.
<i>Action-Specific</i>	None apply.	Action-specific ARARs would be met.	Action-specific ARARs would be met.	Action-specific ARARs would be met.
<b>Long-Term Effectiveness and Permanence</b>				
<i>Magnitude of Residual Risk</i>	No reduction in COC levels in any environmental media.	Contaminated materials remain on site. Significant risk reduction and greater reduction than Alternative 1.	Contaminated materials are transported off site. Significant risk reduction and greater reduction than Alternative 1.	Contaminated materials are transported off site. Significant risk reduction and greater reduction than Alternative 1.
<i>Adequacy and Reliability of Controls</i>	No controls over any on-site contamination, no reliability.	Reliability of caps depends, in part, on long-term maintenance.	Reliability of caps depends, in part, on long-term maintenance.	Reliability of caps depends, in part, on long-term maintenance.
<b>Reduction of Toxicity, Mobility, and Volume through Treatment</b>				
<i>Treatment Process Used and Materials Treated</i>	None.	With earthen cap, waste amended with lime to reduce mobility of COCs.	No treatment process.	No treatment process.
<i>Volume of Contaminated Materials Treated</i>	None.	Upper 2 feet of waste treated with lime at rate of 270 tons per acre. Approximately 3,200 cubic yards per acre of waste amended totaling 2,560 cubic yards.	No treatment process.	No treatment process.
<i>Expected Degree of Reduction</i>	None.	Volume and toxicity of wastes not reduced. Mobility of COCs would be significantly reduced.	Volume and toxicity of wastes not reduced. Mobility of COCs would be significantly reduced.	Volume and toxicity of wastes not reduced. Mobility of COCs would significantly reduced.
<b>Short-Term Effectiveness</b>				
<i>Protection of Community During Reclamation Action</i>	Not applicable.	Fugitive emissions control may be required during construction.	Fugitive emissions control may be required during construction and hauling.	Fugitive emissions control may be required during construction and hauling.

**TABLE 6-11**  
**(Continued)**  
**COMPARATIVE ANALYSIS OF ALTERNATIVES for the**  
**BIG CHIEF-GOLCONDA MINE SITE**

<b>Assessment Criteria</b>	<b><u>Alternative 1</u></b> No Action	<b><u>Alternative 2</u></b> On-Site Repository	<b><u>Alternative 3</u></b> Off-Site Disposal at the Washington Mine Site Repository	<b><u>Alternative 4</u></b> Off-Site Disposal in the Leach Pad #1 Repository
<i>Protection of On-Site Workers During Removal Action</i>	Not applicable.	Expected to be sufficient. Appropriate safety and personal protective equipment would be used.	More construction hazards than Alternative 2 because wastes are hauled. Protection expected to be sufficient.	More construction hazards than Alternatives 2 and 3 due to extended hauling. Protection expected to be sufficient.
<i>Time Until Removal Action Objectives are Achieved</i>	Not applicable.	One field season.	One field season.	One field season.
<b>Implementability</b>				
<i>Ability to Construct and Operate</i>	No construction or operation involved.	Limited space available on site for repository. Construction materials are well understood and available. Some difficulties expected with excavation in drainages. Dewatering, surface water diversions necessary. No other difficulties anticipated.	Easily constructed. Materials and methods are well understood and available. Some difficulties expected with excavation in drainages. Dewatering, surface water diversions necessary. No other difficulties anticipated.	Easily constructed. Materials and methods are well understood and available. Some difficulties expected with excavation in drainages. Dewatering, surface water diversions necessary. No other difficulties anticipated.
<i>Ease of Implementing More Action if Necessary</i>	Does not inhibit other actions from taking place at the site.	Waste materials located within a lined repository not readily accessed without destroying cap and liner. Other site activities outside of repository easily implemented such as additional armoring and stabilization, or other methods.	Waste materials located within a lined repository not readily accessed without destroying cap and liner. Other site activities outside of repository easily implemented such as additional armoring and stabilization, or other methods. However, implementation of future actions is easier than for Alternative 2.	Waste materials located within a repository not readily accessed without destroying cap and liner. Other site activities outside of repository easily implemented such as additional armoring and stabilization, or other methods. However, implementation of future actions is easier than for Alternative 2.
<i>Availability of Services and Capacities</i>	Not applicable.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.
<i>Availability of Equipment and Materials</i>	Not applicable.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.
<b>Cost</b>				
<b>ESTIMATED TOTAL PRESENT WORTH COST</b>	<b>\$0.00</b>	<b>\$170,301 (2a)</b> <b>\$212,212 (2b)</b>	<b>\$214,011</b>	<b>\$259,511</b>

Notes:

ARARs     Applicable or Relevant and Appropriate Regulations  
COC        Contaminant of Concern

Golconda Mine because this alternative will provide the most cost-effective and long-term remedy to protect human health and environmental receptors from waste rock at the Big Chief-Golconda Mine Site.

This preferred alternative includes excavation and disposal of all waste rock in a repository located in the Washington Mine site repository area. The repository would have a geocomposite liner and 18-inch thick earthen cap, and the perimeter of the repository would be fenced. Additionally, the repository cap and disturbed areas would be revegetated. The repository would be constructed as part of reclamation of the Washington Mine site.

Estimated costs of the preferred alternative are shown in Table 6-11. The total present worth cost of the preferred alternative (Alternative 3) is 214,011. This cost includes \$191,555 in construction, engineering, and oversight, and \$1,573 in yearly operations and maintenance for 30 years.

## **6.7 REFERENCE CITED**

- Montana Department of Environmental Quality – Mine Waste Cleanup Bureau (DEQ/MWCB). 2004. Abandoned Hard Rock Mine Priority Site Investigation and Hazardous Materials Inventory. Big Chief-Golconda Mine Site, Jefferson County, Montana 049020. Completed by Tetra Tech EM Inc.
- U.S. Environmental Protection Agency (EPA). 1988. “Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.” U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

**APPENDIX A**  
**FIELD LOGBOOK**

**APPENDIX B**  
**SITE PHOTOGRAPHS**

**APPENDIX C**  
**DATA VALIDATION REPORT**

## **APPENDIX D**

### **RI DATA**

**APPENDIX E**

**RISK ASSESSMENT SPREADSHEETS AND DATA**

## **APPENDIX F**

### **FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**

## **APPENDIX G**

### **STATE OF MONTANA APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS**